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THE CONDITIONS OF MAXIMUM PRODUCTIVE EFFICIENCY.

By Ralph Neville, K. C.

In modern industrial competition for world trade, as Mr. W. L. Clark pointed out in our May issue, Great Britain has the advantage of long undisputed supremacy; Germany, that of a highly perfected commercial system; the United States, the support of the best home market in the world, stimulating specialized manufacturing. The same labor-saving machinery is available to all; the best mechanical practice is substantially public property, open for any to adopt. Mr. Neville's discussion is most significant because he points out that the other factors—the ultimate factors—in the total efficiency of a nation as a producer, are to be found in elements which lie at the very bottom of the social and industrial order. He takes as his text his own country—England—but his argument is no less instructive for either of the other great competitors for the world's engineering trade.—THE EDITORS.

THE history of British industrial development during the last century has been marked by a long period of supremacy almost unchallenged, followed by a short period during which British commerce has been subject to severe competition and has in the result been overhauled with a rapidity quite unexpected. A marked decline in initiative has accompanied this change in position. Heretofore the leaders of the world in the introduction of inventions and the application of new methods and facilities, latterly we have been falling behind; while awakening anxiety exhibits itself rather in a halting endeavour to imitate our rivals, than by any new departure distinctly British. The history of electric lighting, telephonic communication, motor traffic, submarines, and standardisation in the steel trade, serves to illustrate our backwardness; indeed it is not easy to recall any recent practical development in which British industry has asserted its old position as pioneer.

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Opinions differ widely as to the significance of these symptoms, but they are no longer dismissed as the morbid creations of a diseased pessimism. It is improbable that the true remedy for our unsatisfactory position will be found in the imitation of the methods of our rivals, for we are in a later stage of industrial development than they, and are already face to face with difficulties which they have not reached. What is with us at once so necessary and so much to seek, is a clear perception of the conditions essential to industrial efficiency and progress.

The product of the activity of any human society depends upon the character of the individuals composing it, and the character of the individuals composing it directly depends upon the conditions under which the society by choice or necessity lives. The connection between cause and effect in this regard is, in striking instance, generally recognised. The hardihood of the mountaineer is proverbial; slavish characteristics are rightly attributed to the servile condition; as yet, however, it is imperfectly understood, that every characteristic of nation or class has an equivalent cause underlying it, and that amendment of any shortcoming can be arrived at only by the identification and modification of the condition of life to which it is attributable.

Applying these considerations to communities engaged in competitive commercialism, it becomes obvious that, other things being equal, that community will excel in which the conditions of life most tend to ensure diligent application to business. Attention in Great Britain has recently been directed to an alleged excessive addiction to pleasure, among those who may be roughly included in the capitalist class, and to an alleged apathy in the performance of their tasks, on the part of the working class. Assuming these allegations to be correct, they show the existence of two serious obstacles to efficiency; while if the above observations concerning cause and effect are well founded, the cause of these characteristics should be capable of identification, and remediable by appropriate modifications of our social system, so far as it is founded on choice and not upon necessity. It will appear, as we proceed, that necessity has very little to say in the matter. It becomes therefore important to enquire, whether in British social life there exist conditions calculated to produce such characteristics, and the contention which I shall endeavour in this article to sustain is, that in the conventional ideas prevailing in consequence of the undue persistence of feudal conventions and in the method of the remuneration of labour, are to be found

causes quite sufficient to account for the appearance of the characteristics complained of.

In the first place, it may be readily demonstrated that the retention in the social system, of conventions founded upon feudalism, is not, as is generally supposed, merely a picturesque and harmless survival, but that, on the contrary, it is a potent cause, having a far-reaching effect upon national efficiency. It is necessary at the outset to define the meaning of the conventions and conventional ideas spoken of above. By conventions is intended a social arrangement whereby a condition of society not dependent upon natural causes is produced by agreement, expressed or implied, between those who enjoy and those who suffer it. From these conventions flow ideas which are entertained by the people in general, and inasmuch as, of necessity, in any society of human beings, the unalterable realities of life are enormously outnumbered by the conventions by which they are overlaid, it follows that the bulk of the ideas entertained by the majority of mankind are conventional only. Inasmuch, therefore, as the most of men's actions are the result of the ideas they entertain, the actions of men in a social state are to a very great extent the result of the ideas flowing from the conventions which they consciously or unconsciously accept. Consequently the utility of the aggregate of the actions of any human society is largely dependent upon the character of the conventions under which the members of such society live, and their appropriateness to the ends to which the efforts of the latter are professedly directed.

Conventions, in their inception, are directed to the attainment of definite ends, and are usually fairly well adapted to the necessities of the case which they are intended to meet. Hereditary rank and hereditary wealth are good illustrations of pure conventions. They depend upon no natural law, but are founded simply upon supposed convenience and utility. With the conventions regulating the disposal of property after the owner's death we are not at present concerned. Tracing back the history of the convention upon which, to the present moment, the ideas connected with rank are founded, we find it established in feudal times, while the making of the nations was in progress. It was designed to enhance the dignity of those to whom was assigned the administration of law within their territories, and the provision and command of the armed forces of the feudal State, and at the same time to secure an orderly succession to the office. We may note in passing, with edification, the practical good sense of our ancestors, who, differing in this respect from the

continental States, limited the inequality conferred by rank to the necessities of the case, and withheld its dignity and privileges from all but the actual holders of the feudal office—a wise limitation which bore good fruit in the subsequent development of the country. Now any convention which tended to increase the respect of the people for their rulers was obviously a wise convention from the feudal point of view; but the tendency of conventions which have outlived the purposes for which they were constituted is to become obstructive and injurious. It is in the last degree improbable that a convention appropriate to secure a particular end under particular social conditions, should prove to be the appropriate convention to secure another, and quite different end, under other and quite different social conditions. By the change of the structure and objects of society, the utility of this particular convention has determined, while the conventional ideas founded on it, which attribute merit to the possessor of rank and title, remain but little impaired. Out of the numerous instances which might be adduced to establish the accuracy of the last statement, the following will probably suffice. It is a forcible instance, inasmuch as it shows the idea of merit attaching to rank operating in what would appear to be the most unlikely way, under the most unlikely circumstances. Probably no class supplies less efficient directors of limited companies than that composed of peers of the realm, and their immediate relatives; yet company promoters are well aware that the insertion of titled names upon the front page of a prospectus is the readiest road to the public pocket. Repeated exposure of the character of the concerns with which such names have been connected has had little or no effect upon the fascination which they exercise over the public mind. Probably not one in a hundred of those who subscribe their money upon the faith of a great name appearing upon a prospectus—and lose it—could give any intelligible account of the train of thought which led them to apply for shares. They would be the first to ridicule the notion that their loss was due to the undue persistence of a fuedal convention; yet such can readily be shown to be the fact. It appears, then, that not only do ideas flow from conventions, but that these ideas bear practical fruit. Indeed, it is inevitable that where the State confers distinction upon a particular class, that distinction will be associated in the popular mind with merit, and, if the favoured class are not in any particular manner distinguished by merit, then whatever they happen to be distinguished for will be taken, or mistaken, for merit. An hereditary aristocracy, deprived of its occupation and surviving the objects of its existence,

inevitably degenerates into a mere pleasure-seeking class. It is as leaders of a society composing an idle class that members of the aristocracy appeal to the popular mind; and where as with us there is no hard and fast line between classes, the aims and ambitions of every class are largely founded upon the habits of the class above it. Under the present social conditions created and maintained by the State, a natural and inevitable association of ideas leads the public to regard wealth in idleness, not only as the most enjoyable, but as the most honourable, manner of existence; and to esteem business only so far as it conduces to such an end. The truth that in the full exercise of his faculties, lies not only the duty of man, but also the only true source of his enjoyment, is a hard saying; and, in a community seeking efficiency, no effort should be spared to promote the idea that the sole title to esteem consists in what a man is and does, and not in what he has. The deliberate retention of conventions tending to ideas pointing in precisely the opposite direction, cannot fail to materially pervert men's minds from the rational conceptions of existence which lie at the root of the efficient conduct of life.

Immediately connected with the conventional idea which has been considered is the idea of "gentility," entertained in the sense that useful labour is degrading to a "gentleman"; an idea carried so far that "gentleman" came to signify anyone who lived without working, and was legally decided to be the proper description of a solicitor's clerk out of employment. The effect of this perverse idea has been prodigious. It accounts for the low social estimation in which trade and manufacture has been held in Great Britain—a fact which, in its turn, has for generations diverted the more highly educated young men from the pursuit of trade, and divorced the universities from the active life of the country. On the other hand, the abstention from trade of the highly educated led to the association of the idea of imperfect education with that of trade, and, at the same time, fostered in traders a mistrust of the higher education which they believed to unfit a man for business. British commercial development has consequently been retarded by the artificial exclusion of much of the best intelligence of the country from commerce, and at the same time by the imperfect development of the intelligence of those engaged in it; in both cases occasioned by the prevalence of a false conventional idea.

We are not however left to *a priori* reasoning to establish the effect of feudal conventions upon an industrial community. More than a century ago the colonists of America shook themselves free from the trammels of feudalism, and we are enabled to compare the

progress of a nation, free from feudal conventions, with that of the same people left under the influence of their historic institutions and environment. We find in America trade comparatively unhampered by the drawbacks which we have traced to the survival of feudal conventions. Idleness is there not highly esteemed, the display of the energy and capacity necessary to acquire wealth is deemed a higher merit than the possession of wealth itself; the fact that a man owes his wealth to his own exertions there increases, instead of, as in Great Britain, diminishing the estimation in which a wealthy man is held. It is true that America is rapidly acquiring an idle class (rumours of their follies and extravagancies occasionally reach us) for which in due course they will pay the penalty; but it is not large enough, nor has it existed long enough, to affect seriously the conventional ideas of the people; and at least the nation at large avoids the folly of imparting to this class a fictitious importance, by conferring rank and title upon its members. Turning to the question of education we find that in America education is not divorced from business, but the graduate of the university seeks employment in trade, and the man of business looks to the graduate of the university for intelligent assistance. The effect of general education operates essentially towards enlarging the mind and broadening the views, and a country where general education is recognised as the essential basis for technical acquirements, necessarily obtains an advantage in industrial effort over one in which the ignorant notion prevails, that the best preparation for a commercial career is early initiation into the narrow routine of a particular business. As therefore these considerations would lead us to anticipate, we find American employers sparing no expense to reduce the cost of production, and grudging no remuneration to secure the efficiency of labour; while the trades unions, content with the maintenance of a minimum wage, throw little obstacle in the way of the further remuneration of labour in proportion to the work done; in these respects contrasting favourably with British manufacturers and trades unionists. We are forced then, both by reason and experience, to the conclusion, that in the retention of obsolete conventions not appropriate to secure efficiency in business, lies a cause calculated to produce in the capitalist class the very attitude of mind towards business alleged against it; and the truth of the first proposition has been sufficiently established.

With reference to the question of hereditary rank, it is of course neither proved nor alleged that there are not many members of the favoured class in question worthy of the highest esteem; but this con-

sideration only enforces the argument used in that connection, for the respect in which these persons are popularly held is independent of their individual merit, and would remain practically unaltered by its elimination. This is proved by the fact that they share it with others, in whom the merit is nonexistent.

In proceeding to the examination of the second proposition, namely, that the apathy of the working class can be accounted for by the method of their remuneration, attention must be directed to certain conditions involved in the existing relations between capital and labour. In the first place, it is to be noted that where, as in Great Britain, the supply of labour is always somewhat in excess of the demand, the power of dismissal vested in the employer gives him *prima facie* the absolute control over wages; and there is nothing to compel him to maintain them above the point necessary to render the employee temporarily capable of performing the task set him. That wages do actually fall to this point where combination is not resorted to and the conditions stated exist, is shown by the trades in which women are chiefly employed. In such cases the wages paid are often not sufficient to support the life of the employee during its natural term, or anything approaching its natural term. This absolute authority on the part of the employer can, in the absence of legislative interference, be limited only by combination among the employees. Such combination deprives the employer of the power of dealing with any individual in his employ, and compels him to deal with a body which has the power to deprive him, at all events for the time being, of the labour necessary for his enterprise. Combination is therefore, for labour, a prime necessity, and so long as the objects of trades unions are confined to securing a sufficient minimum wage and conditions of labour essential for the health of the employed, their existence tends to the benefit of the whole community, whose first interest lies in securing for all, means of existence compatible with healthy physical development. If the working class could not and did not, to a considerable extent, protect their own interests by combination, legislative protection would be inevitable; while the majority of the Anglo-Saxon race believe the legislative control of individual action to be injurious to the independence of spirit and moral fibre of the individual affected, and oppose its application except in the last resort. We find therefore that the limitation of the power of dismissal by the employer, by labour combination, is an essential condition for the well being of labour and of the State; and, consequently, we must consider the question of the remunera-

tion of labour from the standpoint that trades unions will continue, and ought to continue to exist. The effect of the curtailment of the employer's power of dismissal is not, however, exhausted by its operation upon wages. The employer must *prima facie* rely upon it not only for the regulation of wages, but for the enforcement of the employee's task. Under the wage system the employee has no incentive to exertion beyond the fear of dismissal, and the crippling of the power of dismissal leaves the employer to a considerable extent at the mercy of the trades unions, with regard to the quantity and quality of the work done. In any restriction of effort in which the employee can obtain the support of his union, he is safe from dismissal by any employer who has to accept the conditions of the union; while the exigencies of the trades unions tend to induce them to accept the capacity of the least efficient of their members, as the standard by which to measure the extent of a day's work. Where, with a too narrow regard for their immediate interests, trades unions exceed the functions suggested above as the limit within which their action is beneficial, employers under the wage system must either put up with inefficient labour, or engage in a costly struggle with trades unionism —a struggle in which victory would prove barren, because as has been pointed out, if trades unionism did not exist, legislative interference between employers and employed would be inevitable.

It appears, then, that under the wage system, no incentive to exertion exists, beyond what is necessary to earn the wage, and that this, under existing conditions, is likely to be reduced to a very low point. In the absence of adequate incentive to exertion, apathy is certain to prevail, in spite of the gratuitous advice and exhortation which well meaning persons continually bestow upon the working class. Patriotism, enlightened regard for the interests of British commerce, the stimulating effect of industry upon the moral nature, are in turn called in aid, to induce the working man to give a greater return for his wage than can otherwise be got out of him. In estimating the effect that such considerations are likely to have upon the working class, it is well to bear in mind, that they have no perceptible influence upon any other class in the community, so far as regards the conduct of their business. The members of other classes work for a tangible consideration personal to themselves.

The wage system therefore upon which the remuneration of the working classes is based is not calculated to promote zealous and energetic application on the part of the employee. It throws into direct antagonism the immediate interests of

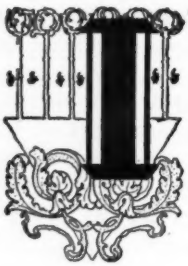
capital and labour; and if apathy on the part of labour does exist, as alleged, we have ascertained a sufficient cause in the method of its remuneration. The conservatism innate in the British character has, in former times of trouble, stood the country in good stead; but in the present industrial crisis it may prove its undoing; for if repugnance to change remains invincible, the wave of progress will pass by, and Great Britain will be included in the category of dying nations, which however slowly, yet surely tend to extinction or absorption by a more effective race. The energy and capacity of the English people however remain as yet unimpaired and a great opportunity is before us if we choose to take advantage of it. The growth of trusts and combines give warning that economic conditions are undergoing a profound change; while the great problems of modern existence remain unsolved. The future is to the nation which shall successfully grapple with the burning questions of the day, upon the solution of which can alone be found the true conditions of industrial efficiency. It does not pass the wit of man to devise methods of distribution which shall put an end to the anomaly involved in the coexistence of over-production and under-supply; so to regulate the relations of capital and labour as at once to close the suicidal strife between them, and to furnish to all engaged in production the incentive to exertion essential to success; so to distribute the population upon the land as to reconcile the pursuit of manufacturing industry with the physical wellbeing of the race. The social and industrial evils by which we are surrounded are the result, not of unalterable realities, but of conditions, if we would believe it, within our control. The industrial difficulty does not arise from incapacity to produce enough to satisfy the requirements of the whole population. Production under modern conditions could be indefinitely increased, did such a system of distribution prevail as to render effective the demand of the masses which at present remains unsatisfied. Over-crowding is not the result of insufficiency of land but largely of an inappropriate system of land tenure.

Efficiency is to be obtained by those only who are prepared to pay the price for it, and the price, in Great Britain, involves the sacrifice of much which is endeared by habit and prejudice. Yet to babble of efficiency while steadfastly upholding the very conditions which make against it, shows a want either of sincerity or of good sense. We cannot hope to hold our own, under modern industrial conditions, without the united effort of the whole nation, and we cannot afford to disregard the stumblingblocks which lie in the way of efficiency.

WAGE SYSTEMS AND THEIR BEARING UPON OUTPUT.

By George N. Barnes.

Mr. Barnes' article is of much value to employers and students of the labor question, because it represents the attitude of the best element of organized labor toward the newer wage systems. It is doubly interesting in its immediate connection with Mr. Neville's paper preceding, as it presents in large part the same subject from the viewpoint of another side.—The Editors.



IT is impossible, I believe, to harmonise the wage system of industry with principles of abstract justice, but it should not be beyond the wit of industrial statesmanship so to smooth its wheels that both employer and employed may extract from it the maximum of advantage for themselves and the community.

Methods of remuneration are, and must always remain, the most interesting and vital consideration connected with enlightened workshop management, because they have a direct bearing upon the human factor in production, and because upon their right adjustment depends to a large extent quiet and peaceful progress. I approach the question with a sincere desire to contribute to that result, and I will endeavour to show that the best method of labour payment is that which, while leaving each workman free to develop to the utmost his own individuality, yet secures every qualified man a fixed minimum income, supplemented by additional payment for increased output.

"The produce of labour," said Adam Smith, "constitutes the natural recompense of labour," the application of the formula, however, being confined to that "original state of things which precedes both the appropriation of land, and the accumulation of stock."

It is difficult to see why the accumulation of stock should lessen the recompense of labour, but it is certain that the ordinary time wages of the worker today bear but little relation to produce. Ownership of stock, and payment of wages by one class of people, and the rendering of services and receiving of wages by another, has brought, and to some extent has necessitated, changed points of view. There are those who regard the worker as a thing to be fed, regimented, and set

in motion much in the same way as a machine tool. There are those who would tie him up to a particular employment and isolate him from his fellows by profit-sharing schemes or other forms of paternalism, and there are others again who still frankly regard the operation of self interest, and its expression in the cash nexus, as the last word to be said in regard to industrial relationship.

I believe that to get the best results from a man you must get him to apply his own free-will and power of initiative, but, at the same time, that you must not so individualize him as to prevent him making common cause with his fellows. It is not a question of the natural recompense of labour with which one has to deal today, but rather a question of how best to adjust methods of remuneration so as to yield the greatest possible productivity consistent with the welfare of the worker, and the maintenance and development of social consciousness on the part of all concerned.

Mere material productivity, it will be observed, is to me a secondary consideration, the human aspect being the first. A man may produce a good deal if his faculties are focussed in a narrow groove; he may be a veritable producing machine if divested of all fellow feeling with those about him, and engaged in a miserable scramble in which the "fittest" are the physically strong, and the morally unscrupulous. But before embarking on this course I should want to know where it will lead.

From earliest times wages have been regarded from the point of view of the dependence and economic inferiority of the worker. The highest conception of wages on that basis finds expression in Holy Writ, in the parable of the equal payment of the labourers in the vineyard, although it must be admitted that the justification offered to those who had borne the burden and heat of the day was scarce calculated to appeal to them very strongly. "To each man his penny" may be regarded as the biblical expression of democratic equality, but the further query "Is it not lawful for me to do what I will with my own?" has been the anti-social plea of tyrants of all climes and times.

For the serf of the feudal ages ways and means were adopted of adjusting wages to the cost of animal existence, and the worker was regarded quite frankly in that sense. From 1563 and, according to Thorold Rogers, for centuries onwards in Great Britain, the magistrates met from time to time to assess wages, and the assessment is said to have had regard "to the price at the time of victuals and apparel." Such is the origin or germ of the much vaunted "living wage" which, after all, is but a variant or development of the "cost of

living" wage of the serf of the feudal ages. It presupposes the worker to be and perpetuates him as a mere drudge—a man without hope, stimulus, or interest in his work, but entitled only to a bare living from it, whatever the product; and it exhibits the employer as the head and cornerstone of the industrial hierarchy, and the only man with scope for initiative. In addition to this, it is now open to the further objection that time wages, under intensified competition in industry, tend to a "payment by results" basis; the remuneration received having a distinct relation—tacit or expressed—not to the value of the product, but to the amount of work done.

I believe, therefore, that the time-wage method alone is unsatisfactory—is a mere expedient, acceptable only to a habit of mind cast in a state of semi-feudalism. On the other hand, Louis Blanc's famous dictum "from each according to his ability, and to each according to his needs" depends for its realisation upon far-reaching political changes, and is applicable only to a more advanced state of civilisation. We have to deal with facts as we find them, and devise some method whereby, without destroying fellow feeling or lessening social consciousness in the workshops, men may yet be given greater interest in their work, become more efficient in it, and at the same time enabled to get more out of it.

The two modifications of the time rate which have been from time to time persistently attempted in the engineering workshops are individual piece work and profit sharing. The first has been a failure, and the second cannot be regarded as a success. In the stress of competition, piece-work earnings have tended to slide downwards to what had previously been regarded as a time-work wage, and even below it. Men with this experience in view have become less efficient because, conscious of injustice, they have lost interest in increased production; and employers, instead of finding out the cause and removing it, have railed against the men, and especially against trade-union organisations, as if trade unionists were responsible for what, after all, was the inevitable result of a defective method of remuneration.

In some cases a contract gang system has been adopted, work being let out to contractors who have hired and paid their own labour, generally on time wages, and this has led to minute subdivision of work, with consequent lowering of the general standard of skill, and an even more unsatisfactory division of the product than individual piece work. I believe that piece work has failed because it has not been accompanied by any provision for safeguarding the interests of the men.

Such provisions are, I believe, absolutely necessary, and they should include some arrangement as to fixity of the piece-work prices. They should also provide either that the employer and the men collectively should agree upon a standard list of prices; or, if the employer prefers to deal individually with the men (thus practically fixing the prices himself), that he should fix them so as to yield average earnings over and above time-rates pay, and should guarantee the payment of a minimum weekly pay to each man whom he cares to continue in employment at all. If either of these methods were adopted each man would be encouraged to work at full speed, and could do so without injury to his fellows. Individual interests would be protected by the principle of collective bargaining being given effect to; or, if an employer arranged prices with the men so as to yield additional earnings —and it would be to his interest to do so because of increased product—the men would undoubtedly earn such additional wages by increased intelligence in their work.

Profit-sharing schemes are open to objections of quite another character. I do not think that they are calculated to contribute to the permanent solution of industrial problems, although I admit that they have been advocated by many well-meaning and amiable people, and have been put into practice, sometimes with advantage, in industries where labour of a low and unorganised grade has been employed.

The profits or losses of an industrial concern now-a-days depend upon many things with which the workman has, and can have, nothing to do. Skill, or otherwise, in buying and selling, speculation, the effects of varying prices, arrangements made on this hand or on that—in short, any one of fifty things quite unrelated to the skill and efficiency of the workman concerned, may wipe out profits at any time. Moreover, ascertainment of profit can obviously be made only at long intervals of time, and workers in profit-sharing workshops are prone to remain there till profit-sharing time, and thereby they lose touch with fellow workers elsewhere. Profit-sharing schemes have indeed sometimes been inaugurated for the express purpose of thus wedding workers to particular employments and detaching them from the unions of their fellows, thus disintegrating labour into isolated and conflicting groups of workers, whereas progress is on the line of the mobility and combination of labour as well as of capital.

Combinations are necessary, not only to enable each side to protect and advance its own special interests, but to bring out the best men on both sides, and to give effect to the best means of industrial adjustment. They afford means by which men are brought together

with full sense of responsibility, and armed with powers of giving effect to the largest amount of common-sense existing among them.

Another system of payment by results is the premium system, and this I believe can be so arranged as to be capable of smooth and mutually beneficial results, provided there is thorough organisation and fair dealing on each side.

It is primarily a method of increasing output and reducing cost of production, but incidentally it may also raise the position of the worker and give him greater interest in his work. It is different from piece work in two respects. First, it presupposes the payment of the time rate of wages as a basis; and second, it is less open to cutting of prices or time limits. I believe that in both these respects it is superior to piece work. The worker is automatically protected against undue cutting by the day wage being secured, and by the fact that the benefit, if any, by cutting does not all fall to the employer. As originally introduced the plan was to pay a certain fixed premium per hour saved—generally one-half—but I believe that the modification introduced some time ago by Mr. James Rowan, of Glasgow, which is known as the Rowan system, is preferable, because it still further reduces the temptation to cutting. Thus, suppose under the "half-and-half" system a job be timed 10 hours, and the worker completes it in:—

9	hours,	he	would	receive	9	plus	½	hour,	or	5.5	per	cent.	increase	of	wages.
8	"	"	"	"	8	"	1	"	"	12.5	"	"	"	"	"
7	"	"	"	"	7	"	1½	hours,	"	21.4	"	"	"	"	"
6	"	"	"	"	6	"	2	"	"	33.0	"	"	"	"	"
5	"	"	"	"	5	"	2½	"	"	50.0	"	"	"	"	"
4	"	"	"	"	4	"	3	"	"	75.0	"	"	"	"	"
3	"	"	"	"	3	"	3½	"	"	116.0	"	"	"	"	"
2	"	"	"	"	2	"	4	"	"	200.0	"	"	"	"	"

And under the Rowan system if a piece of work is timed at 10 hours and the worker completes it in

9	hours,	he	would	receive	9	plus	9/10	hours,	or	10	per	cent.	increase	of	wages.
8	"	"	"	"	8	"	16/10	"	"	20	"	"	"	"	"
7	"	"	"	"	7	"	21/10	"	"	30	"	"	"	"	"
6	"	"	"	"	6	"	24/10	"	"	40	"	"	"	"	"
5	"	"	"	"	5	"	25/10	"	"	50	"	"	"	"	"
4	"	"	"	"	4	"	24/10	"	"	60	"	"	"	"	"
3	"	"	"	"	3	"	21/10	"	"	70	"	"	"	"	"
2	"	"	"	"	2	"	16/10	"	"	80	"	"	"	"	"

Under the original plan it will be noted that the saving is divided so that the proportionate advantage to the workman—proportionate, that is, to his time wages—increases with the saving effected; thus on a "half-and-half" arrangement, a man who saved 2 hours from 10

would increase his wage by 12½ per cent.; if he saved 5 hours from the 10, his wages would be increased by 50 per cent.; and if 6 hours, by 75 per cent. These increasing gains with increasing product, therefore, would still leave temptation in the way of the employer to cut the time limits, and indeed would seem to justify it, having regard to estimated and actual time of doing a job in extreme cases. Mr. Rowan's system, on the other hand, gives the man an increase of wage equal to the saving effected from the time limit; thus if a man reduces a 10 hours limit by 2 hours, or 20 per cent., his wages would be increased by 20 per cent.; if by 3 hours or 30 per cent., 30 per cent.; and so on, the man getting a greater immediate advantage on the first saving effected, but a less, as compared with the other method, in proportion as there is greater saving.

It is sometimes objected to on the part of those who prefer to adhere to the time method of payment that the premium system is unfair, inasmuch as it does not give the worker the whole saving. In regard to this it may be pointed out that under time wages more stringent discipline may result in saving without giving the worker any advantage at all. The premium system, as compared with time payment, has the double advantage of securing greater product by the exercise of mental and manual alertness of the worker, stimulated by self interest instead of by more exacting and irritating supervision, and it secures for him part of such increased product; the remaining part going, not altogether to the employer, but part to the customer through lessened cost of production.

Objection is also sometimes raised to the premium, or bonus, plan of payment that it gives the workman only a part of the resultant saving, whereas piece work, it is said, gives him the whole of it, and it is also urged that the employer thus takes something to which he is not entitled. Thus, Mr. Frank Richards, of New York, in a paper read to his fellow members of the American Society of Mechanical Engineers, says, that the employer should pay "*pro rata* for all work turned out, as he is certainly paid in that way for all the product of his shop." I believe that the argument itself, and the statement here quoted in support of it, are fallacious. Piece-work rates are cut down so that, although under piece work the whole of the work done may be paid for *pro rata*, it by no means follows that the price is maintained at a point higher than wages, plus premium, under a premium plan. The probability is that after a very short time piece-work prices would be lower. There is, further, an implication in Mr. Richards' argument that the employer gets paid *pro rata* for increased output on a

premium system, and at the same price as obtained prior to the introduction of such system, an implication that does not correspond with facts. Under competitive industry—monopoly values apart—a lessened cost of production tends, as has been said, to lower prices, so that as a matter of fact the advantage tends to the consumer rather than to the employer, the gain of the latter being rather in increased business and larger turnover on a given capital.

"Oh, but" it is then said—the old idea of a fixed quantity of work dying hard—"increased business of one employer must mean decreased business of another." The answer is that a new demand is attracted by lower prices, to what extent it is impossible to say, but at all events it is safe to say that want of work need have no terrors to engineers, in an age when electricity in its bearing upon the development of the engineering industry is just beginning to be felt.

I conclude that there are no valid economic arguments against the premium system. Provided that it is begun and continued in good faith, there being mutual agreement in fixing time limits, and extra pay given for extra time, I see no reason why it should not be operated with mutual advantage to employer and employed. But much depends upon the method of its introduction, and the spirit in which it is approached. Here the human element comes in. It may be grafted onto a workshop without serious disturbance of ordinary methods of production or workshop practice, the men being stimulated to increased effort by the ordinary play of self interest and good-will; but on the other hand, it may be thrust on a workshop so as to upset and replace existing practice, and reduce men to automata.

I should place the scheme outlined by Mr. H. L. Gantt in the latter category. As put forward by its author in a paper read to the American Society of Mechanical Engineers in December 1901, it appears really as a system of task work, the basis time being fixed, not from experience of day-work average records, but from the results of calculations carried out by one man in a workshop, and thrust by him upon all the others, thus divesting them of all power of initiative or discretion in their work. "Detailed instructions as to the way of accomplishing each of the elements of the work in the time" are provided for. "An expert mechanic has charge of what is known as the 'routing' of the piece through the shop." "The kind of tool to be used, the feed and the speed, are specified for every machine in operation," and, worse than all, provision is made for the foreman receiving "definite premium for each machine under his charge that makes bonus."

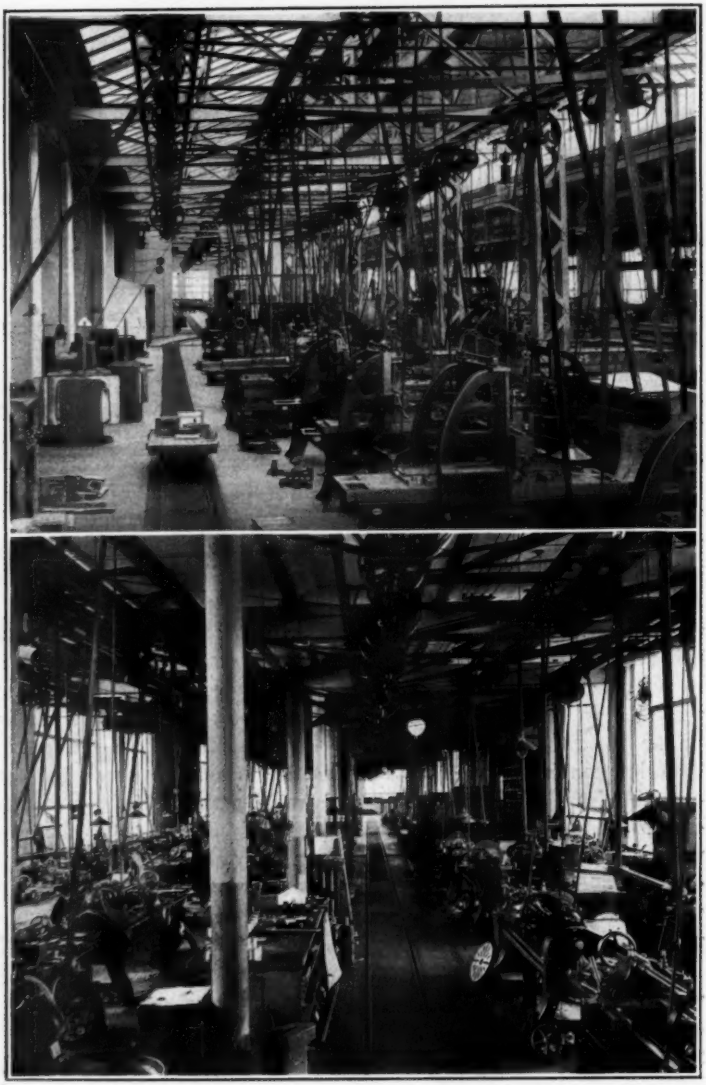
The inclusion of the foreman as receiver of premium or bonus is really the re-introduction of the old piece-master system, which wrought such incalculable injury in the engineering trade many years ago, and which has been practically abolished in Great Britain, although its effects are still seen in some industries. In the cotton-weaving trade, for instance, it has led to infamous driving of helpless female labour to such an extent as to lead not infrequently to suicide. The "router" is also quite as objectionable a person—in fact, many readers will have "rout" in mind rather than "route" in reading Mr. Gantt. The function of the "router" I should say is to harry and bully the men as much as to determine the order of the operations on a piece of work through the shop; in fact, the idea underlying the whole scheme would appear to be to harass and drive a lot of timid and spiritless men to earn a bonus, much in the same way as a donkey is spurred to increased exercise by the dangling of a carrot in front of his nose, and the "routing" of his haunches with a big stick.

No provision is made in this scheme for the payment of extra rates for extra time, which provision is a feature of the premium system as in operation in Great Britain, or for re-adjustments, or for any element of mutuality; there is, in fact, nothing in it but a hard-and-fast, inelastic, inflexible, and mechanical operation of a system working from a centre, and based upon the assumption that men are mere things to be wound up, like pieces of mechanism.

In conclusion let me say that I am opposed to any method, no matter how successful in production of goods, which works out in undue regimentation of specialised labour. Recent observation in America convinced me that specialisation has there proceeded far enough, if not too far, already. It is robbing the workshops of mechanics and filling them with men whose daily life precludes the possibility of developed individuality. For, after all, men are to a large extent made or marred by the circumstances of their daily life, and no system or method can be truly successful which fails to take cognisance of that fact.

Methods of remuneration and workshop management generally should aim at protecting and encouraging the weak, curbing the morally unscrupulous, and leaving the average man room to live and grow—in other words, should give all men share in the extra advantages as well as extra labour incidental to intensified forms of production, and thus harmonise individual with collective well-being.

The Editors of course allow Mr. Barnes free expression of his views concerning all systems of wage payment. They hope in a succeeding number to give Mr. Gantt's own exposition of his conception of the remuneration of labor.



PART OF THE LUDWIG LOEWE & CO. WORKS, BERLIN. ONE OF THE NEWEST AND LARGEST GERMAN MACHINE-TOOL BUILDING ESTABLISHMENTS.

The upper picture shows the light planing department; the lower, the turning department. The floors, lighting, adjustable shaft-hanger system, and industrial railway are particularly to be noted.

WORKS DESIGN AS A FACTOR IN MANUFACTURING ECONOMY.

By Henry Hess.

Works management logically should begin with the direction of the first design for the plant, and it is from this point of view, with the concrete example of a design which was actually carried out, that Mr. Hess discusses the topic. The manager may not often have had equal opportunity to arrange his works, but he may yet find much of interest in the study of ideals toward which gradual rearrangement or radical reorganization may proceed. The illustrations represent both types of shop—those designed new to occupy wholly new sites, and those which by success have far outgrown their original bounds and have been readapted to cope with the demands of the new conditions.—The Editors.

WORKS design includes broadly all elements that enter into the planning of a works up to the point of starting the machinery on actual manufacturing. As the term "works" itself may be made to include plants for producing on a large scale every article made for the use of man or beast, it is to be understood at the outset that though much that is said below will apply even in this broad sense, machine-building works are referred to more specifically. The various mainheads are referred to in the order in which they naturally come up for consideration.

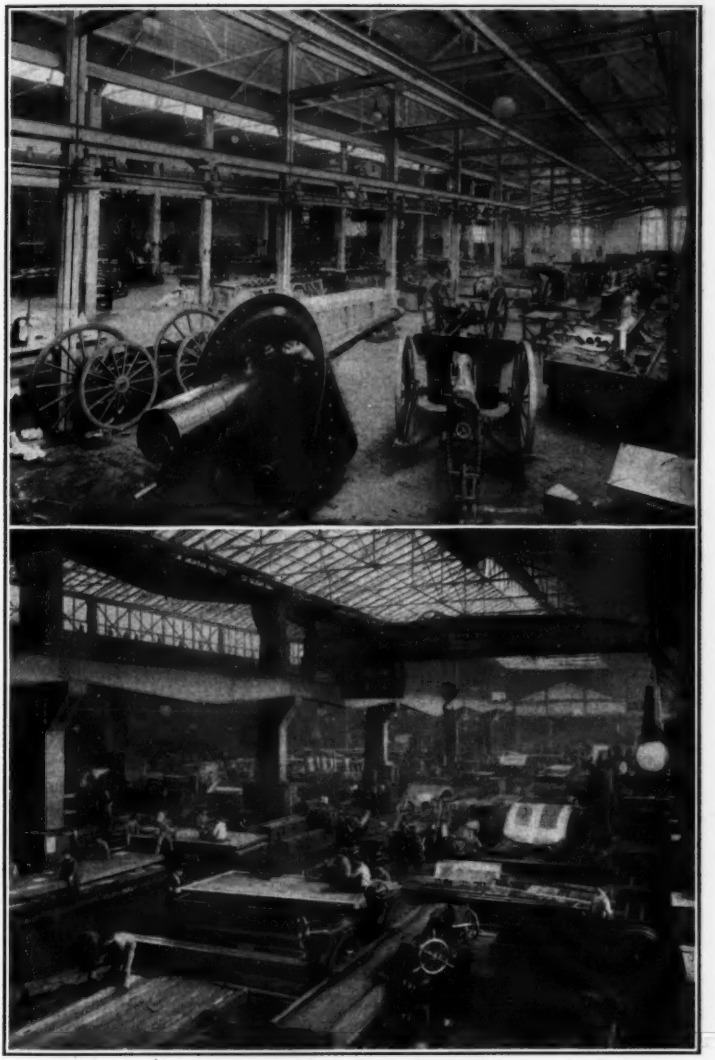
The Site.—It is not always—in fact, it is rarely—that this can be selected solely with a view to its complete adaptability to the branch of manufacture in question; yet it is vital that it should at least approximately correspond to the needs of the special case. In general, it may be said that the more largely material enters as a factor of cost compared with labor, the more vital will correct choice of the site be. An ideal site will be level, will have a sandy clay soil over a subsoil of gravel and clay, will be located directly beside railway or waterways or both, and will have good trucking roads. Once in a way a site may be found with all these desiderata and at a reasonable cost, but not often. Falling short in one particular or another, it will become the duty of the designer to consider carefully the relative costs of site, of shipment, of foundations, etc., in making a choice. First cost should weigh less than items that will cause continually recurring expenses; should the available means not be sufficient, then increased running costs must be accepted as an unavoidable handicap. Adequate railway shipping facilities will, as a rule, be more important than

convenience of shipment by water; railways are available the year round, and will also average less trans-shipment en route both for raw material and product. If the chief item of cost in manufacture is labor and the product not too bulky or heavy, then good trucking roads to a railroad and a cheap site will be preferable to direct railway conveniences and a costly site.

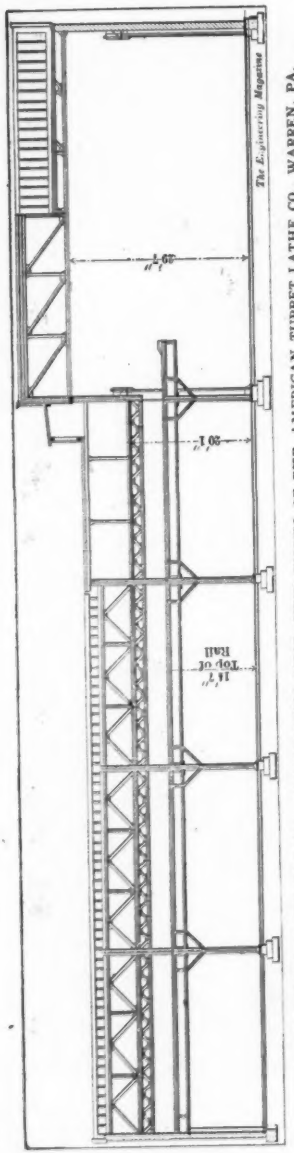
In selecting the site due regard should be paid to the labor element. There must be an assurance that labor will be not only abundant, but also of the right quality. Vicinity to large cities is not advisable; the city itself will always offer inducements that will make work in the city preferable, so that the works outside will get only the flotsam and jetsam. A site in the city itself will generally be too costly for all but light manufacturing. A site at a considerable distance will have an initial disadvantage in procuring labor, but once procured it is apt to be steady; such location may bring about the necessity of investing capital in workmens' dwellings; that need not be a deterrent, and certainly not a handicap on the manufacturing economy, since such investment can readily be made to bring a fair return. It should, however, be considered a separate investment. Indirectly, the steadiness of reliable labor will tend to manufacturing economy.

Ground Plan and Elevation.—Having determined on the site, the general ground plan must be worked up. That this should be laid out so as to ensure a steady forward progression from point of receipt of raw material to shipment of finished product, is today so well understood that the statement has all the air of a trite commonplace. For all that, it is not infrequently sinned against. Then comes the question of advisability of one or more floors. For heavy work there can be but one voice as to the desirability of ground-floor shops, possibly with galleries for some of the lighter work. For medium work the cost of ground-floor space will govern the selection. For light work several floors will be preferable; aside from the advantage of smaller capital investment in real estate, the cost of transportation of work in progress will be less from floor to floor, than over the necessarily greater distances of single-floor shops; it is assumed that ample elevator facilities are provided. This presupposes also that the width of shop and location with reference to its surroundings will allow getting light in generous amount to the middle; unless this is the case, single-floor construction is preferable.

The work to be performed must now be analyzed as to its main stages. The buildings should be so arranged that the first operations can be carried on as close to the point of receipt of raw material as



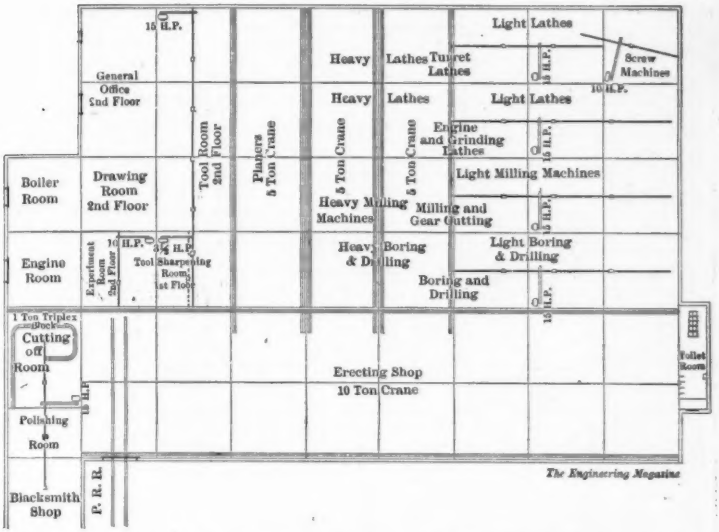
THE UPPER PICTURE SHOWS THE NEW GUN SHOP IN THE WORKS OF THE JOHN COCKERILL CO., SERAING, BELGIUM. THE LOWER IS TAKEN IN THE ARMOR-PLATE DEPARTMENT OF THE GREAT KRUPP WORKS AT ESSEN, GERMANY.



SECTION ACROSS MACHINE SHOP AND ERECTING SHOP, NEW WORKS OF THE AMERICAN TURRET LATHE CO., WARREN, PA.

is practicable, and the last operations similarly near the point of shipment, or of storage awaiting shipment. Operations that from noise, smoke, or other nuisance would hinder other work, should be carried on in separate buildings, or in sections suitably partitioned off. If the work does not have to pass the various departments one after another, but consists chiefly of details coming together for final assembly, the various departments should be suitably grouped near the assembly department and all at practically the same distance from it. The same consideration holds for semi-finished products that represent an aggregation of operations. The two methods of advancing the work from raw material to finished product may be likened to "series" and "parallel" work in electric wiring, with a combination of the two analogous to "compounding."

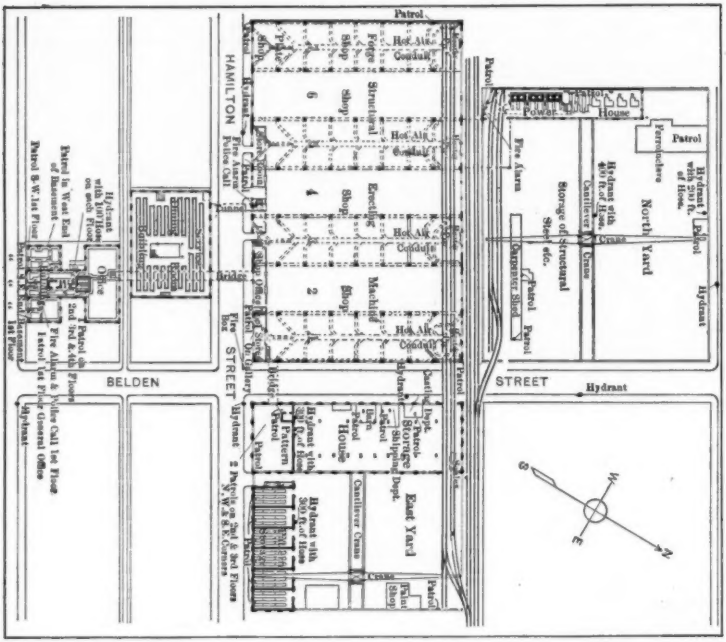
Height will have to be governed by the necessities of the product, and considerations of lighting, heating and ventilation. Great height is generally called for only in erecting departments for large machinery. Other departments, however, should not be stinted in this respect, as otherwise a good distribution of natural and artificial light, equable heating, and good ventilation, are difficult of attainment. Where cranes are needed these should be given plenty of headroom, and the floor plan and distribution of machinery so arranged that a minimum number of cranes may be widely distributed, or again concentrated,



GENERAL GROUND PLAN OF NEW WORKS, AMERICAN TURRET LATHE CO., WARREN, PA. The planer department and the two adjacent departments, at right angles with the erecting floor, are covered by 5-ton cranes. The smaller tools, under a lower roof, are at right angles with the planer section and parallel to the erecting floor. Each lineshaft is driven by an independent motor; the larger tools under the traveling cranes are individually driven. In the screw-machine section, as will be seen, the shaft is set at an angle.

with the varying demands made on their service. It is always advisable to design for a very much larger plant than it is intended to build, and so to arrange ground plan and elevation that subsequent enlargement and rearrangement of the machinery is not hindered by the building itself. That means that the building should be an assemblage of similar units, and not be composed of units each adapted specifically to the machinery it is to contain at the outset. If this is done, subsequent enlargement and consequent shifting of tools to maintain the original steadily forward progression of the work can be had with a view solely to economy of manufacture. It will also be found that buildings laid down along these lines will not be a hindrance later to taking up a new line of manufacture.

Power Plant.—This will be governed largely by the available source of power, whether coal, gas, or water; electricity will as a rule enter only in competition with shafting as a distributing agent. Usually the location of the plant will govern the relative cost of power, and with that the choice. The conflicting claims of shafting and electricity

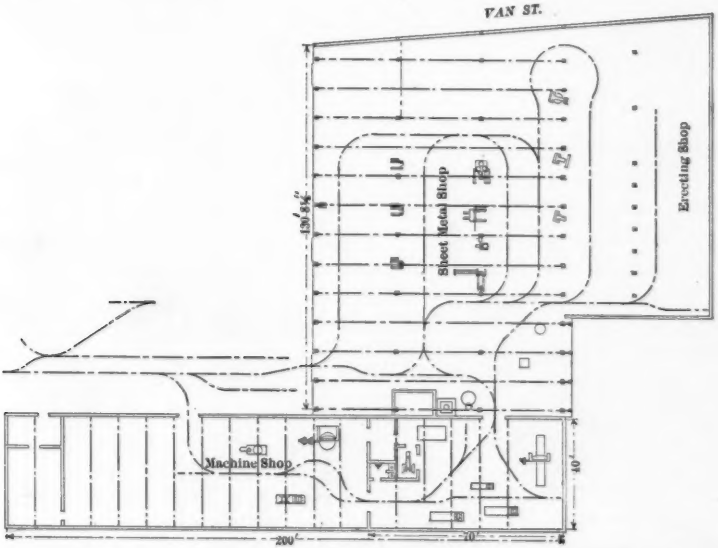


GENERAL GROUND PLAN OF THE SHOPS OF THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO.

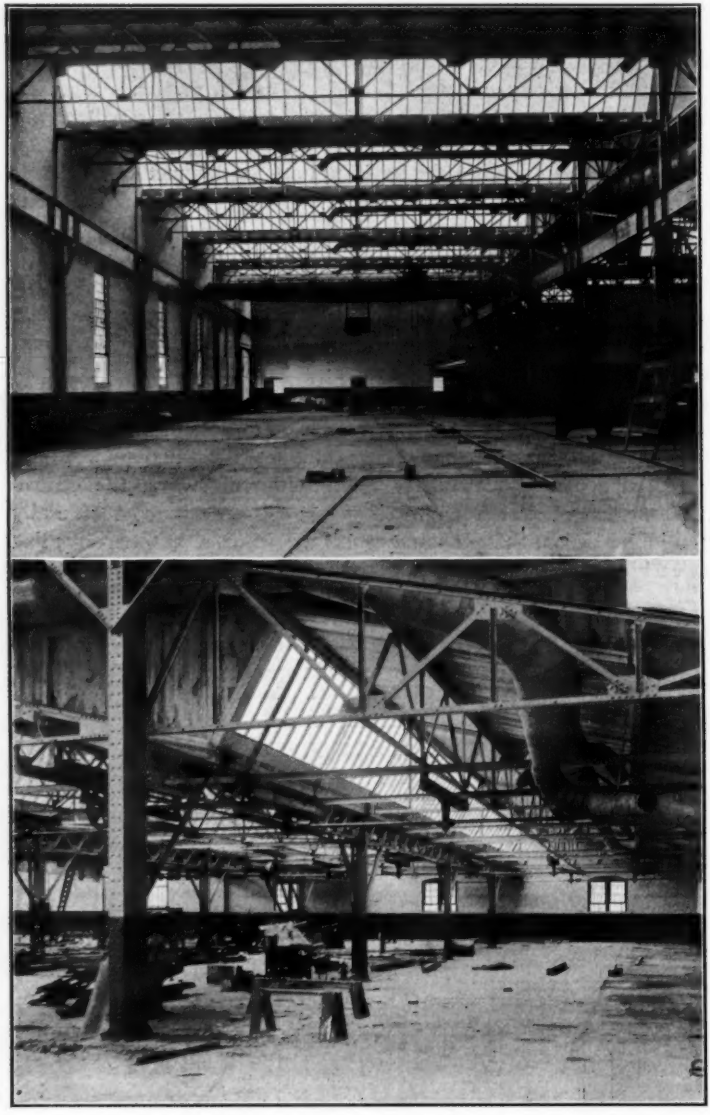
for distributing the power will have to be carefully considered; not only first cost of installation, but also subsequent convenience and indirect influence on economy of production should govern the choice. It may be said that for most lines of manufacture in which the individual machines do not require more than 10 horse power, distribution by electric current rather than main lines of shafting will be ultimately the most economical. In sections of the country that call for much more will be found to promote economy, particularly so when the larger machines have to be forced and worked over time; that will often be the case in machine-building industries, since the heavier tools are so costly that the equipment is very likely to fall somewhat short of a complement full enough to balance the output of the smaller tools in the same working time. Properly designed individual driving will also conduce to working economy, as the greater handiness of speed changing will induce the workman to make use of its possibilities and so save time and increase his output. Smaller machines will

be best grouped in units of from 10 to 25 horse power. If, owing to high cost of floor space, it is advisable to crowd machines together, individual direct motor drive of even the smallest tools will permit going farther in this direction than group driving. The first cost, with careful adaptation of the building itself to this method of power distribution, will vary so little that mainly questions of continuous running costs should govern the choice; as a rule these will be less when machines are not too closely crowded.

Lighting.—Abundant light, properly distributed to avoid cross lighting, glare, and heavy shadows, is an element of economy not easily over-estimated. To get in plenty of daylight cannot be said to be expensive or even more costly than to build without this in view. There are many well known types of single-floor construction to select from to suit the needs of any particular case. For low or medium high shops the English sawtooth is very good indeed; for medium and high shops, particularly if they are fitted with craneways, the central monitor with vertical sidelights is good; this type is most generally used in the United States; better still is a form used in Germany; this is clearly shown in the sectional diagram on page 514; the roof rises to



OUTLINE PLAN OF MACHINE, SHEET-METAL, AND ERECTING SHOPS, THE C. W. HUNT CO., WEST NEW BRIGHTON, STATEN ISLAND, N. Y.



TWO VIEWS OF THE AMERICAN TURRET-LATHE CO.'S NEW SHOPS, WARREN, PA.

The upper is the erecting shop, in which the saw-tooth roof is a novel feature. The features of lighting, heating and ventilation, crane service, and relation of machine shop to erecting departments are noteworthy.

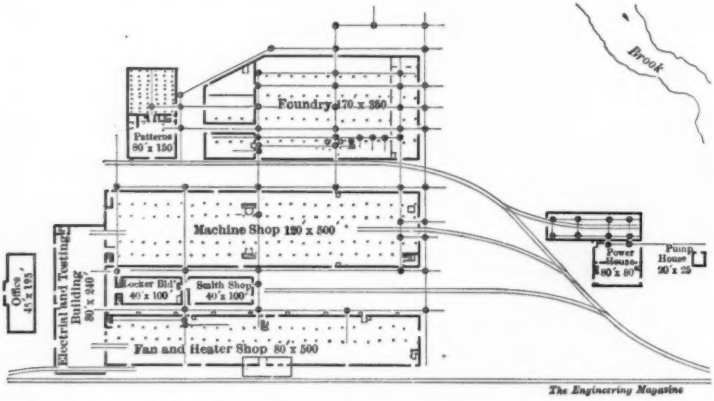
the ridge in two pitches; the outer flat pitch is dark, the central steeper pitch is of glass. A reversal of this arrangement has the flatter dark portion next the ridge, which is then joined to the walls by the steeper pitched glass sides. Both forms are equally good as regards giving light to the interior, but the second form is not suitable for shops built in aisles; it will then not let in as much light, and be difficult to keep free of snow in the sharp deep gulley found at the junction of two aisles. The form illustrated has been found to be practically self-clearing of snow though the agency of ordinary winds aided by the interior

MACHINE SHOP IN THE NEW WORKS OF MESSRS. GRAHAM, MORTON & CO.
Showing craneways, industrial railway, and lighting arrangements.

warmth of the shop. The material of the skylights is of the utmost importance; it should permit the passage of as great an amount of light as possible and yet prevent all glare; that means finely ribbed or ground glass, preferably of a yellow tint rather than green or white; in default of that the glass should be lightly coated with thin grey paint—not lime wash, as that flakes and is ultimately more expensive from necessity of frequent renewal. For all but vertical skylights, wire-glass should be employed. Some flexible substitute for glass would be very good; I believe that there is such a substitute which

has been used with very good results, but cannot speak from personal experience.

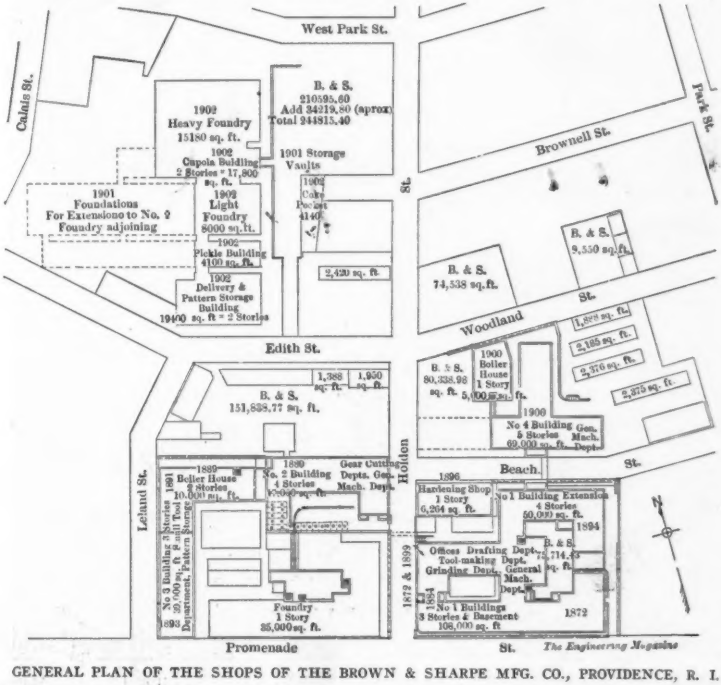
The importance of adequate lighting at night is an element of manufacturing economy only secondary to that of day lighting. The electric light is practically the only one to be considered. Arc lamps for general illumination will cost least; they should be so hung as to give an even distribution without heavy shadow anywhere. It will be best to determine their location experimentally after all the other shop equipment that reaches over fifteen feet from the floor is in place. On the whole, they are best hung fairly high, so as to be above the ordinary upward glancing line of vision of workmen even at some distance; if that is done, and the amount provided is liberal, very much less secondary lighting by less efficient incandescent lamps will be needed; usually a portable hand lamp with convenient bracket will then answer for most machines.


Brook
Foundry 70 x 350
Patterns 80 x 150
Machine Shop 120 x 500
Power House 60 x 80
Pump House 20 x 25
Locker Rm's 40 x 100
Smith Shop 40 x 100
Office 45 x 125
Electrical and Testing Building 80 x 340
Fan and Heater Shop 80 x 500
The Engineering Magazine

OUTLINE PLAN SHOWING ARRANGEMENT OF NEW SHOPS OF THE B. F. STURTEVANT CO., JAMAICA PLAIN, MASS.

Heating and Ventilation.—These two matters must be treated jointly as they affect one another; both are important elements of the cost of production as they seriously concern the comfort and well being of the workmen and therefore indirectly their working capacity. For large open shops moderately warmed air, forced into the shop near the roof at moderate speeds and pressures and in sufficient volume to renew the air about three times an hour, is best; this need not be more expensive of installation than any other system. In the United States this method is very well known and considered standard,

but in England and Europe it is little known and meets with much opposition. In Germany heating by forcing in hot air has been tried, but failed; the air was greatly heated, and then forced in in too small volume; the mistake made was in attempting to heat the large body of shop air by the addition of a small body of relatively hot air, instead of supplying the entire volume of air in renewal and moderately warmed. For low or small rooms a similar system can be economically employed, but must be much more carefully designed to secure even distribution and avoid enervating blasts of warm air. The plant should be of sufficient size to secure a shop temperature of about 55 degrees F. with the average outside winter temperature when taking all of the air from outside. For exceptionally cold weather it will then answer to use part of the shop air over again. Ventilation is to be secured by arranging openings in the apex of the roof or at the sides of the monitor; it will be best to arrange for closing these during very


West Park St.
Calais St.
Park St.
Brownell St.
Woodland St.
Edith St.
Beach St.
Leland St.
Holden St.
Promenade St.
1902 Heavy Foundry 15180 sq. ft.
1902 Cupola Building 2 Stories 17,800 sq. ft.
1901 Foundations For Extension to No. 2 Foundry adjoining
1902 Light Foundry 8000 sq. ft.
1902 Pickle Building 4100 sq. ft.
1902 Delivery & Pattern Storage Building 19400 sq. ft. = 2 Stories
B. & S. 210595.60 Add 34219.80 (aprox) Total 244815.40
1901 Storage Vaults
1902 Cary Pocket 4140
2,420 sq. ft.
B. & S. 74,538 sq. ft.
B. & S. 9,550 sq. ft.
1,898 sq. ft.
2,185 sq. ft.
2,376 sq. ft.
2,875 sq. ft.
1900 Boiler House 1 Story 5,100 sq. ft.
B. & S. 80,336.96 sq. ft.
1900 No 4 Building 5 Stories Gen. Mach. Dept. 69,000 sq. ft.
1,388 sq. ft.
1,950 sq. ft.
B. & S. 151,535.77 sq. ft.
1899 Boiler House 2 Stories 10,000 sq. ft.
1899 No. 2 Building 4 Stories 60,000 sq. ft.
Gear Cutting Depts. Gen. Mach. Dept.
1896 Hardening Shop 1 Story 6,264 sq. ft.
No 1 Building Extension 4 Stories 50,000 sq. ft.
1894
B. & S. 74,714.43 sq. ft.
Offices Drafting Dept. Tool-making Dept. Grinding Dept. General Mach. Dept.
No 1 Buildings 3 Stories & Basement 108,000 sq. ft.
1872
1872 & 1899
No. 3 Building 3 Stories 1901 20,000 sq. ft. Mill Tool Department. Pattern Storage
1893
Foundry 1 Story 35,000 sq. ft.
N

The Engineering Magazine

GENERAL PLAN OF THE SHOPS OF THE BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

An example of successful growth and extension amid a rather contracted environment, under the impulse of a rapidly increasing business.

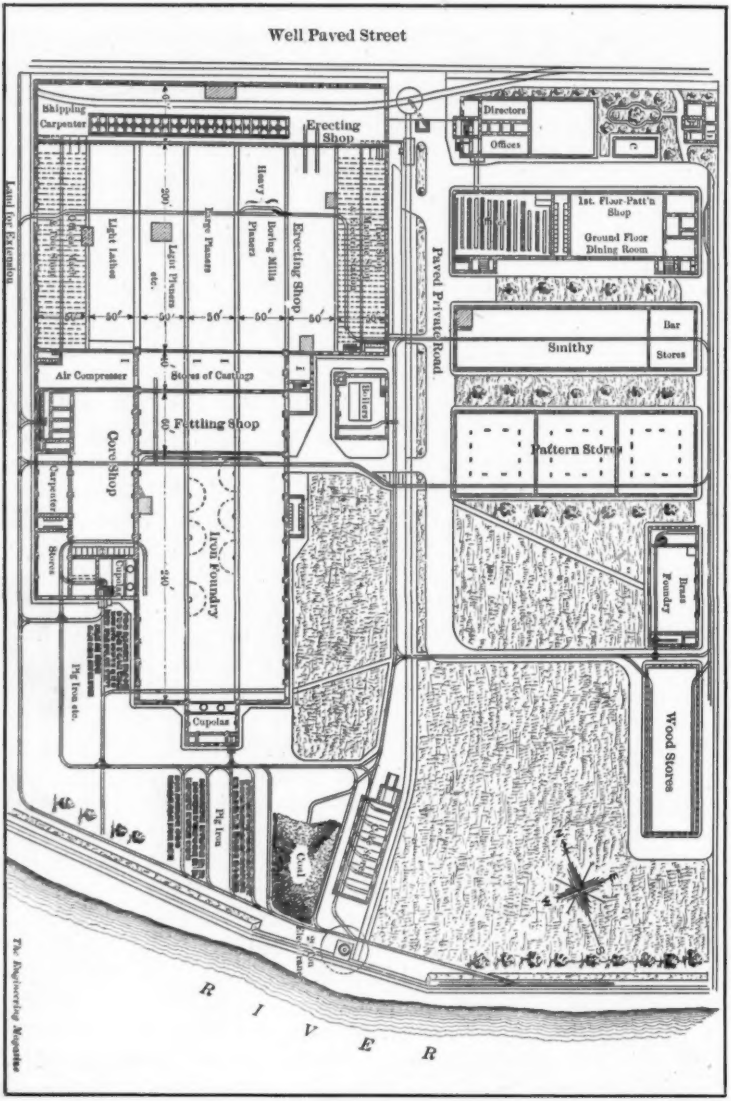
BRASS MACHINE SHOP AND A PART OF THE GENERAL MACHINE SHOP IN THE BALDWIN LOCOMOTIVE WORKS, PHILA., PA.

cold weather. In warm weather the air can be kept moving by the fans of the heating plant just described; this can be usefully employed further to actually cool the air during very hot weather by drawing it over the winter heating coil, which is then supplied with cold water instead of steam. The side windows should not be depended upon for ventilation, unless they are placed very high. Within reason, height of shop will conduce to better ventilation as well as to more even distribution of warmth and light.

Heating of smaller shops by direct steam piping may also be well done, and will usually involve less initial outlay than hot-air heating as described; it can not, however, give as good results in providing an atmosphere most favorable to the employees' working ability as the hot-air method at its best, and is therefore less to be recommended if maximum running economy is aimed at.

Sanitary Arrangements.—Washing facilities should be ample and coupled with a place for cleanly storage of clothes; this will indirectly affect manufacturing economy through its influence on the self respect of the workers. Luxury is not called for—is in fact out of place. Closets should be conveniently located to the place of work, to avoid loss of time; they should not be located in dark corners inviting a quiet occasional loaf and smoke. The question of sewage disposal can be settled only in accordance with local conditions.

Machinery Arrangement.—The location of each and every machine should be carefully determined beforehand and not left to the happy inspiration of the moment when the tools begin to come in. There are two broad points of view governing choice of location. Either a full complement of tools is to be provided for each separate product, corresponding to the idea of individual shops, having only a central purchasing and selling department and head manager, or the machines are to be purchased and grouped solely with an eye to the performance of analogous operations in departments specially designed. The first method calls for a larger initial outlay for plant, and will also require rather more foremen; with it there is less liability of disturbance in final erecting from an operation or part having been forgotten or not finished in time. The second method has the possibility of finer cutting down of time and cost of performing the various detail operations, and requires less foremen and a smaller number of tools, which latter can also be more concentrated. If its possibilities are to be fully developed, it must be given a highly competent rate-fixing staff. The drawing room also must restrict itself carefully to the use of standard forms; this is not by any means easy



GENERAL GROUND PLAN OF THE DEUTSCHE NILES-WERKZEUGMASCHINEN-FABRIK, BERLIN.

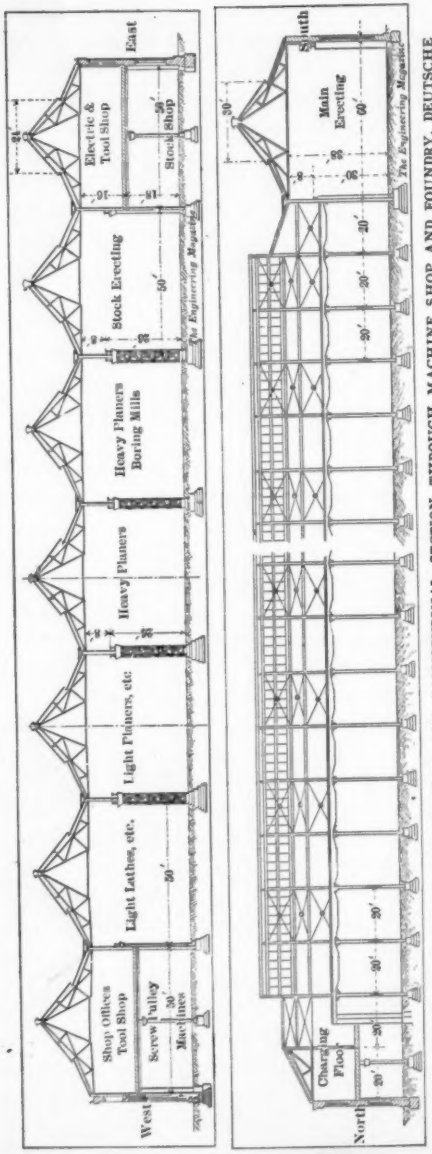
of attainment even in the United States, where standards and labor saving are in the air. Where part of the product is likely to be built in relatively larger numbers, and part only a machine at a time, it is advisable to create separate departments for these two classes. Certain special work, such as gear cutting, is best taken care of in a special department that delivers to the others. Heavy machines should not be duplicated in the two departments, unless there is enough work in each to keep each set fully employed.

Foremen, clerks and others having to do directly with the shop work should have conveniently located offices as central as possible to their work; these offices should be partitioned off for the sake of cleanliness and occasional privacy; the original design should include an equipment for accessible filing of all pertinent data; more than mere mention of such equipment is not pertinent to the subject now under consideration, but comes under the head of works management and system.

General Stores, etc.—For a large works it is best to have a receiving store department conveniently located with reference to the point of receipt of goods and their distribution; subsidiary or distributing storerooms, which may often be conveniently coupled with tool rooms, should then be located as centrally as possible in each department. For a smaller works a combined receiving and distributing store, centrally located, will be best. Central location does not necessarily refer to the geometrical centre, but rather to convenience to the natural avenues of travel of men and goods.

A plant designed by the author for the building of medium and heavy-weight machine tools may serve as an application of the principles laid down. The ground plan is shown on the opposite page.

The works was intended, as just stated, for the building of medium and heavy-weight machine tools. The parties financing the venture decided to put up a plant having a capacity sufficient to employ about 1,200 men to start with, and to be independent of outside foundries, etc. They also wished to have more than usual attention paid to general appearances, and to such matters as arrangements for workmen's conveniences and comfort, even at enhanced cost. They had selected a site in a small but growing manufacturing community within ten or fifteen minutes of a very large city, by frequent railway connections. This site had river frontage, the well paved main street of the town with a railway track on the opposite front, and a paved road connecting the street with the river front along one side. While somewhat costly, this was not considered an obstacle, as values had



CROSS SECTION THROUGH MACHINE SHOP AND LONGITUDINAL SECTION THROUGH MACHINE SHOP AND FOUNDRY, DEUTSCHE NILES-WERKZEUGMASCHINEN-FABRIK.

been regularly increasing and were sure to keep on doing so.

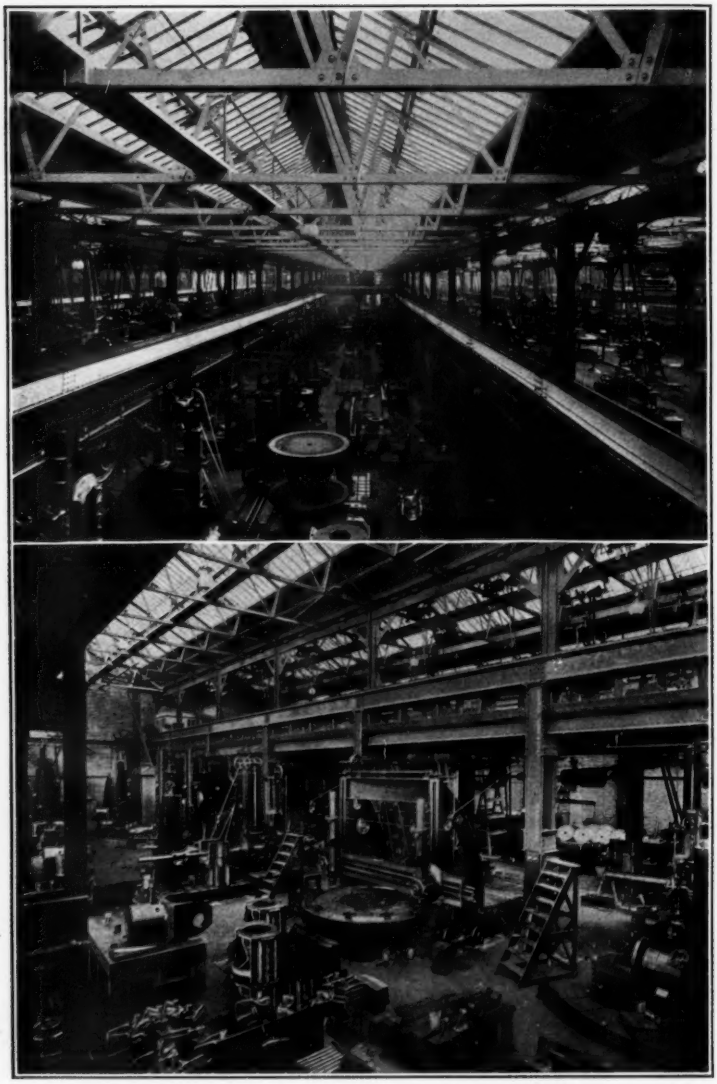
This was the condition when the designer was called in.

Careful borings showed that the soil was in general of a good reliable character for even heavy buildings and called for little piling; there was a top layer of rather loose sand, so that all free spaces were later sown in grass to bind this. Trees were allowed to remain as far as possible. A mill on the other side of the river had the right to build a bridge, and with that a street approach; this compelled laying out the paved private road about 500 feet from one side of the boundary, and also determined the placing of all of the subsidiary buildings on the narnower plot so divided off, and of the main shops on the other. As rough stores, such as pig iron, coke, coal, etc., were, during the open season at least, most cheaply brought in by water, the shop for

first operations—i. e., the foundry—was placed toward the water front. Storage was therefore also provided there, ample enough to permit purchase during the open season sufficient to carry the works through the winter and save the higher railway freights. A full-gauge railroad track was carried down the dividing street to make the storage spaces accessible also by rail. The covered coke sheds were placed alongside this track. The main shipment of finished machinery was to be by rail. This brought the erecting shop nearest to the main-street front with its track; a siding was laid directly through the erecting shop, which was therefore also placed parallel to the main street. The machine shops were all placed at right angles to the erecting shop.

A casting-storage room was placed at right angles across these and between them and the cleaning room of the foundry, which was placed parallel to the storage room. The foundry was arranged beyond the cleaning and storage rooms practically as a continuation of the machine shops. The main cupola was located at the lower end of the foundry; a lighter cupola was placed at about the centre of the foundry on the western side. The charging floors were made commodious enough to accumulate material for two days heat; a second cupola beside each of the original ones was provided for.

A study of the plan will now show that pig and coke were received at the lower end of the foundry, molten metal was carried forward lengthwise, and rough castings were carried forward along any one of three foundry aisles to the cleaning room terminating these aisles. From the cleaning room they were carried directly into the store room, or beyond this into the lengthwise aisles of the machine shop, and from these to the erecting bay in which all of the shop aisles terminate. In those shop aisles in line with the foundry aisles the heavy machinery was placed, so that heavy castings were carried forward only in straight lines, from casting to erection. Craneways were laid continuously through shop and foundry aisles over the intermediate storage and cleaning rooms. This reduced handling to the utmost limit, and also permitted the use of a smaller number of cranes. At casting time the shop cranes could help out the foundry, while at other times the foundry cranes could help out the machine shop. Dirt was excluded from the machine shops by a system of sliding and rising partitions. An exhaust fan in each skylight was also planned in case the partitions should prove insufficient. Actual experience has proven that the rather costly partitions could have been omitted; with the given conditions of shop height and roof construction and ventilation,

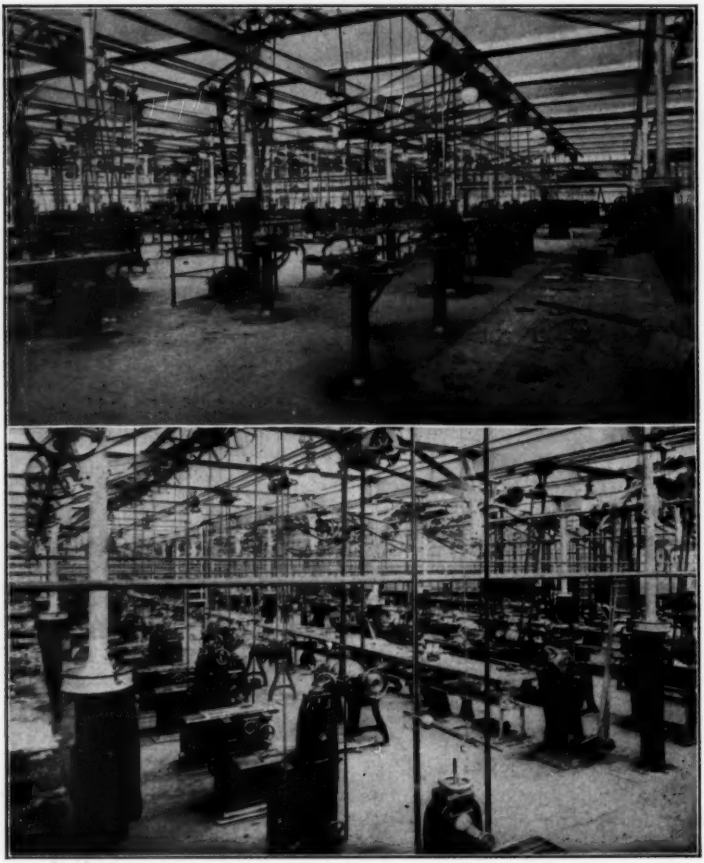


GUN-MOUNTING DEPARTMENT (ABOVE) AND CARRIAGE DEPARTMENT (BELOW) IN THE ERITH WORKS OF MESSRS. VICKERS SONS & MAXIM, LTD.

exhaust fans in the skylights would have been all sufficient, even without running all the time.

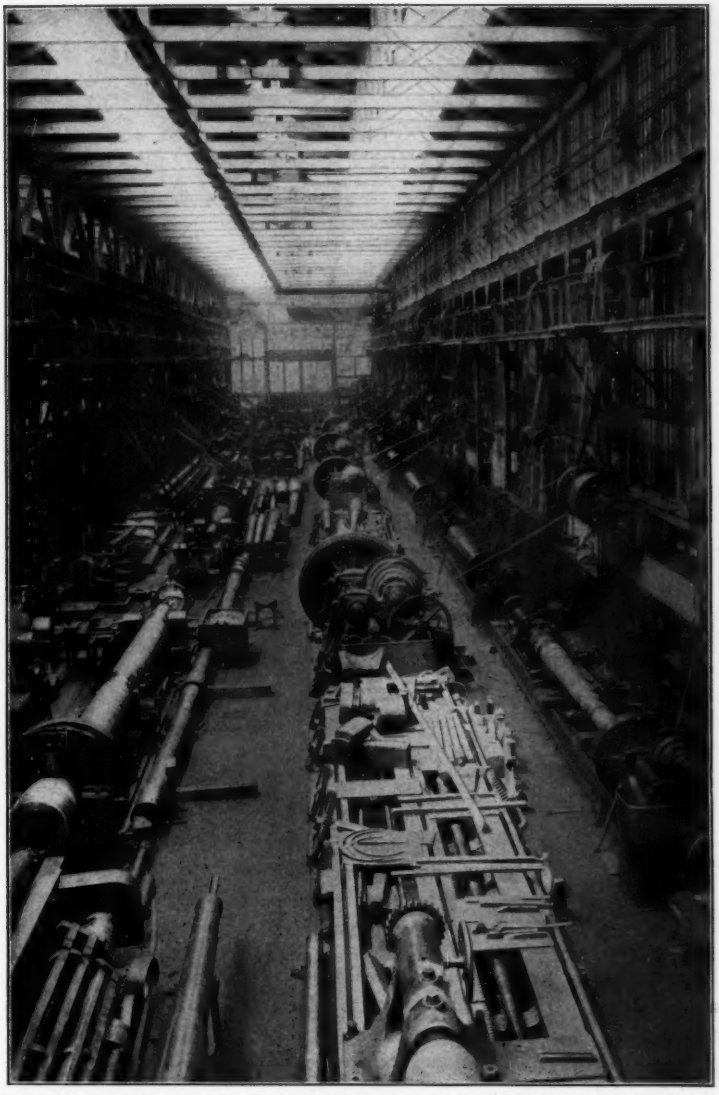
Lighter machine work was performed in other aisles paralleling those for the heavy work. The last aisle of each side was provided with a gallery of the full width of the aisle. The two aisles to the east were set aside for the building of certain machines in larger lots; the second aisle was intended mainly for erection.

The tool-making shop for this department was placed on the gallery. The balance of the gallery was given up to the various switchboards, etc., of the electric plant. In the east aisle were placed also the general milling and gear-cutting machines as a separate department, serving both divisions of manufacture. All the rest of the shop was given up to the building of machines in single lots. This latter department also had its own separate tool-making room on the west gallery. Here also were placed an office for the engineer who looked after shop methods and designed shop tools, etc. All the parallel aisles, whether in shop or foundry, had exactly the same cross section and roof construction; extension was planned for by adding parallel aisles on the west side; columns and crane girders were built into these walls so that no disturbance would be created by such extension. The first extension of the foundry would be one or two aisles to the east, and after that as many as might be called for to the west. The subsidiary foundry departments, such as core rooms, ovens, small stores, etc., were housed in lower buildings of less costly character to the west; they were therefore close to the actual moulding floor, and would later not be expensive of renewal. First extension through to the east would give an increase of foundry floor of two-thirds, so that the probability of renewal of these buildings was too remote to weigh against the advantage of immediate proximity. A room for housing an air compressor dovetailed nicely between core room and machine shop. A power plant was not put down, but power derived at reasonable rates from a neighboring generating station controlled by capital interested in the shops also. A small boiler house of relatively inexpensive character was put up in the eastern angle between shop and foundry to supply steam for the heating plant during the winter. Four air-heating and distributing units were placed at I, I, I, and I; the two central ones over the casting store in the roof, another in the compressor room, and the last in a small annex to the east that also housed a paint and saddlery shop and foundry offices. These heating plants were thus centrally located with reference to the machine shops and foundry and also close to the steam-generating plant.



MILLING AND TOOL-MAKING DEPARTMENTS OF THE LINOTYPE COMPANY'S WORKS, BROADHEATH, MANCHESTER, ENGLAND.

Of the subsidiary buildings, that for the offices was naturally placed next to the street. Then came a two-story building with general drawing room and pattern shop above, and the washrooms with canteen below. Next came the blacksmith shop; this was placed here so as to bring its entrance in line with the side entrance to the machine shops; the rear portion of the smith shop was lightly partitioned off and devoted to the storage of current material, such as bar steel, etc.; here also were located cutting-off saws, centering machines, and



ONE BAY IN THE ELSWICK WORKS OF MESSRS. W. & G. ARMSTRONG, WHITWORTH & CO., NEWCASTLE-UPON-TYNE.

These celebrated British ordnance and marine-construction works have been recently noted for some of the most advanced experiments with the new high-speed tool steels.

straightening press; all material was therefore delivered from the smith shop ready for the lathe. Owing to the absence of steam during the summer months and the presence of an air compressor for driving pneumatic drills, hoists, chippers, etc., compressed air was used also for the steam hammers. Direct measurement of power for compressing the air gave rather high costs; it is difficult to say in just how far its use tended to economy in saving labor; on the whole, the evidence is favorable when running approximately with a full force and less so under conditions of slack work.

Next comes the pattern store house; this was located with reference more to ready communication with the foundry than with the pattern shop, as demanded by the preponderance of relative traffic. This building was divided by fire walls and double sliding doors into three bays; the first one of these was employed as a general storeroom. It was assumed that with the need for taking in this bay for pattern storage there would also be a call for enlargement of the main shops; it was then intended to place the general stores in these. All of these subsidiary buildings were dimensioned very liberally for the rest of the plant, as the projectors of the enterprise thought enlargement likely to be required in a time that would not justify the extra cost of enlargement of originally smaller buildings, as compared with the interest on capital invested in building liberally at the outset. A brass foundry was placed convenient to the rear end of the pattern store house; finally a lumber shed with open cage sides was placed beyond this and parallel to a paved road running along the rear of all of these subsidiary buildings. A system of Hunt tracks provided for ready intercommunication in short straight lines among the various shops and stores. A liberal equipment of trucks of various patterns further helped cut down the cost of moving material about.

The height of buildings, arrangement of roofing, and skylight, were all found to be favorable to lighting, heating, and ventilation. Construction and other data can be gathered from the various sectional elevations given.

All elements tending to an increase or to undue height of fixed charges must be most carefully considered; this is particularly necessary where a market must first be found or a reputation earned. In such case the output will for some time to come in all probability be small, so that high fixed charges may readily stifle an otherwise very promising undertaking.

THE TOOL ROOM AND ITS FUNCTIONS IN COST-REDUCTION.

By John Ashford.

The tool equipment is the producing machinery of every machine-building and metal-working shop. The importance of keeping this equipment at the point of highest efficiency needs no demonstration, but the conception of an organized department devoted specifically and solely to that end is comparatively recent. Mr. Ashford's article following is the first part of a comprehensive treatment of the problem; the second portion, which will appear in our August number, will deal with "The Proper Tooling of Machine Tools."—THE EDITORS.

PERHAPS it would be well, at the commencement of an article dealing with the tool room, to state clearly what is meant by such a branch of an engineering workshop, at least so far as this article is concerned. By the words "Tool Room" then, is meant that branch of a modern machine shop wherein all small tools, jigs, templates, measuring appliances, etc., are made, stored, and preserved in a satisfactory working condition.

The great aim of every works manager is to obtain rapid production at low cost, and the tool room is a most important factor in securing such a result. That such a department is a necessity in a modern engineering establishment, will not be doubted by any manager who has once had one in successful operation. Large works there are that have been raised into positions of prominence without the aid of a recognised tool department. No doubt this was possible, because the conditions then existing were different from those of to-day; for, in the days of the past, engines and machines were *engineered* into existence by the aid of general utility tools and much skillful fitting and erecting, whereas now they are *manufactured* by specialised rapid-production machinery with the help of accurate measuring appliances and assemblers.

The word "engineered" is here intended to imply a process of origination and building up, coupled with the making of some parts to suit others already made, perhaps, without the aid of templates and gauges and without consideration for interchangeability. On the other hand, the word "manufactured" is intended in this instance to mean the production of standardised parts in quantity, such parts being produced independently of other parts, by special machinery,

accurately to gauge and with small error limits. When so manufacturing, accuracy of measurement is usually enforced by rigid inspection, so reducing the work of fitting and erecting to practically a process of assembling, and also, ensuring interchangeability.

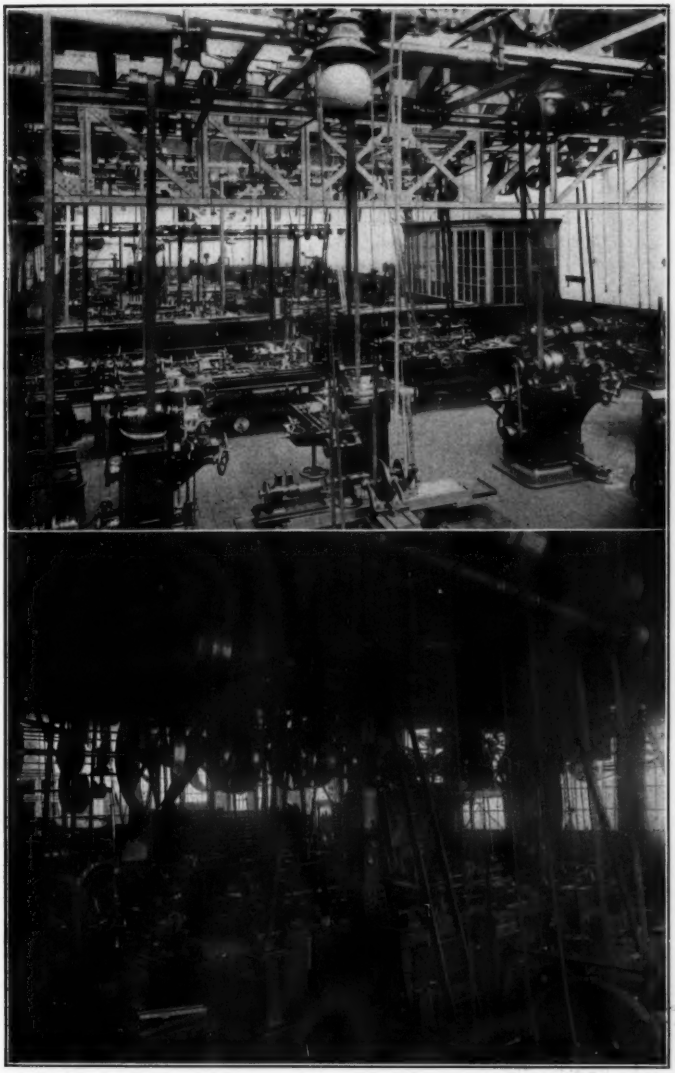
These two methods of production practically represent the conditions of the past and present. The general-utility machines, such as lathes, planers, slotters, and drills, were usually equipped with the simplest of tools, made by a smith and ground to shape by the machinist himself; and as limit gauges, micrometers, verniers, and jigs were almost unknown, the need for a tool room was not felt. Observe the difference in the modern shop that must have its limit gauges, twist drills, reamers for hand and machine use, the variety and assortment of turret-lathe tools, gang drills, form tools, jigs, and other special appliances and measuring instruments. These latter are all necessary to obtain the degree of accuracy requisite for perfect interchangeability, while using highly developed machine tools capable of doing given work in a fraction of the time hitherto possible.

Modern manufacturing methods must be adopted by all who desire to be in the front rank, and coupled with these methods there must be a modern tool room or its equivalent, otherwise high-class machine tools cannot be used to advantage.

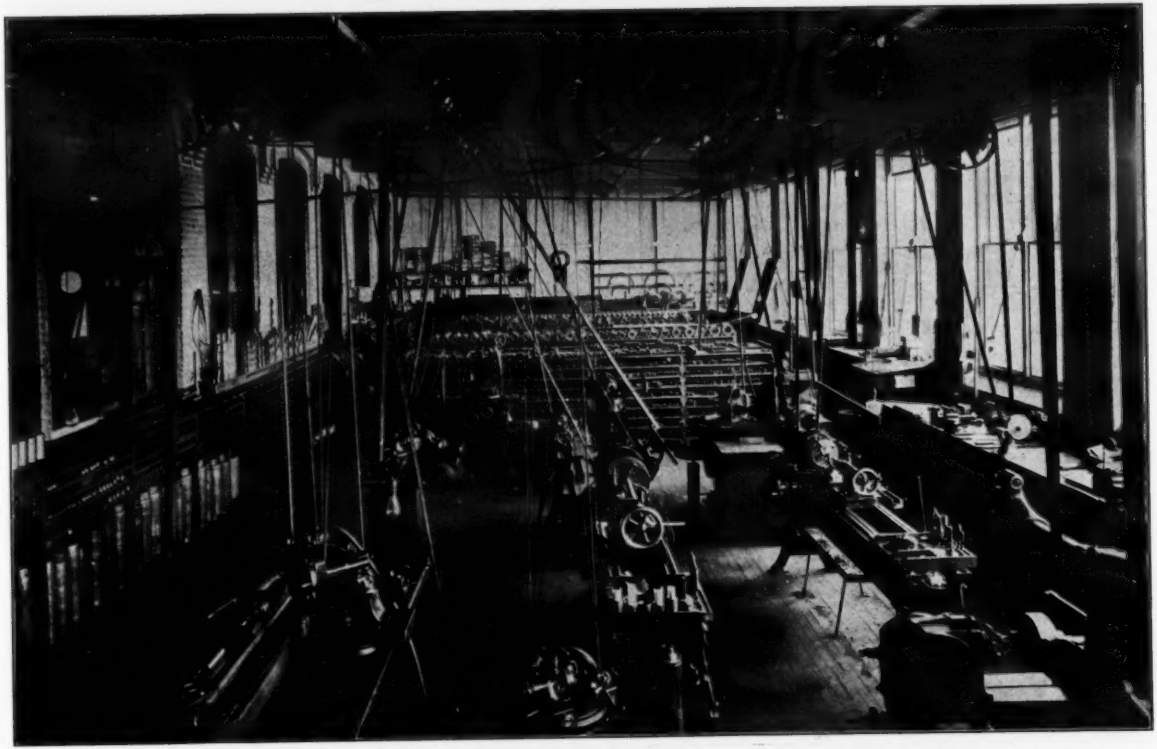
Before dealing more particularly with the functions of the tool room, it may be of interest to some to consider briefly its equipment and location, together with a few other general points, assuming that such a department is about to be established.

The Location of the Tool Room.—If the shop is comparatively small, it is advisable to select a fairly central position, so that the tool store may be easily accessible from all parts, and, when possible, the tool room should be in close contact with the store. A good position for the tool room may sometimes be found upon an upper floor or gallery, with the store immediately below connected by a stairway and a light hoist. Due consideration should be given to the possible future need for expansion, both of the tool room itself and the store. The situation should be as light as possible, and the floor, if above ground, needs to be sufficiently rigid to avoid excessive vibration. The probable temperature should also be noted to ensure a fair mean, without extremes. By all means let the tool room and store be divided from the other portions of the shop, and let it be an offense for the ordinary workman to enter it without permission. It should be looked upon as a prize and a mark of ability for the man in the shop to be accorded a place in the tool room.

In a large works, it will no doubt be necessary to have several tool

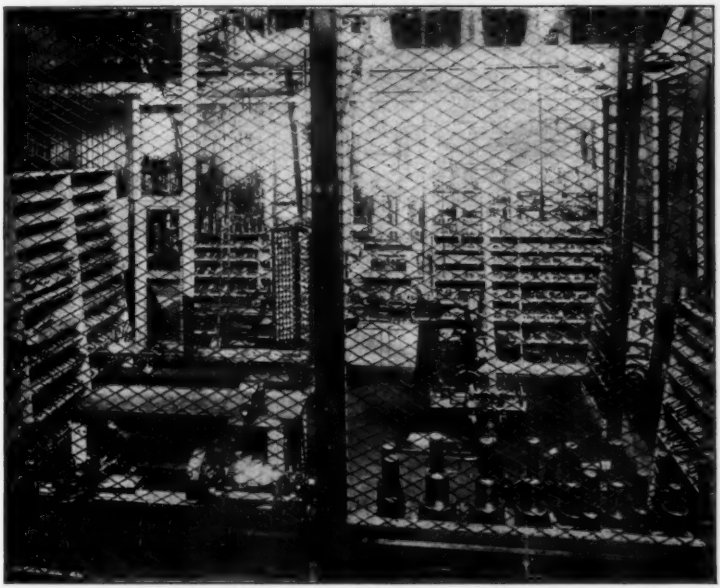


THE UPPER ILLUSTRATION SHOWS THE TOOL ROOM OF MARSHALL, SONS & CO., LTD., BRITANNIA IRON WORKS, GAINSBOROUGH, ENGLAND. THE LOWER ONE SHOWS THE TOOL ROOM OF THE NILES TOOL WORKS, HAMILTON, OHIO.



TOOL ROOM IN THE POND MACHINE TOOL WORKS OF THE NILES-BEMENT-POND COMPANY, PLAINFIELD, N. J.
At the end are seen the storage racks, illustrated in more detail on page 541.

stores conveniently situated for the various parts—such, for instance, as a store for the turret-lathe department, another for the milling department, and still another for the turnery and drilling sections, according to the shop arrangement. In this case the actual position of the tool room will be less important, as the stores are, of necessity, severed from it. The plant that will be required will include:—

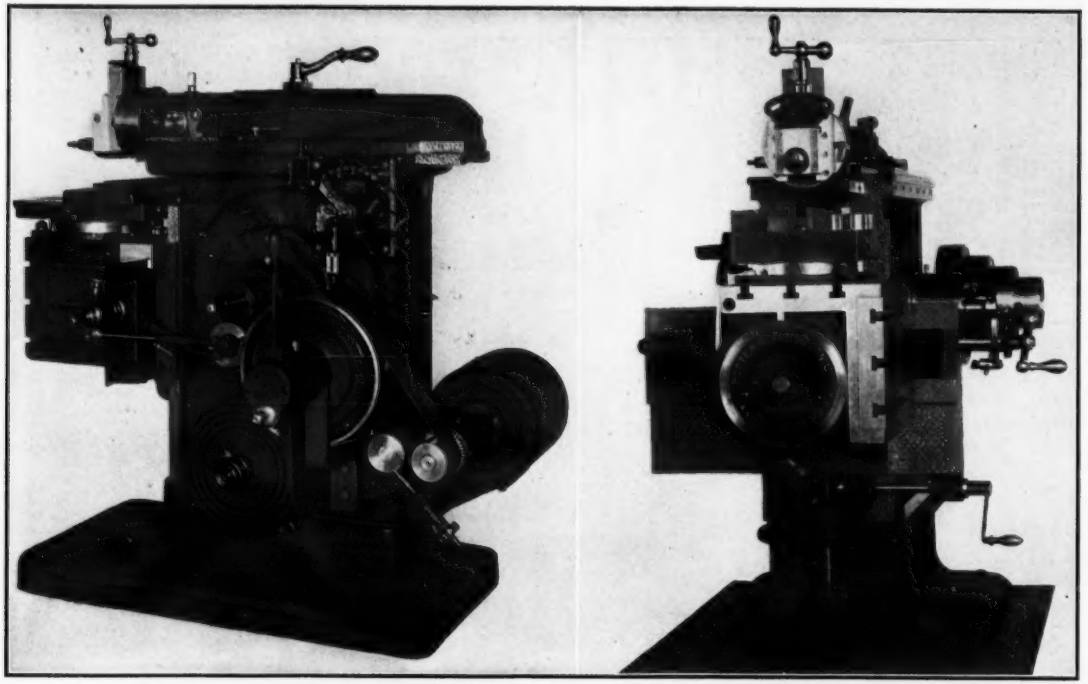


ONE OF THE SMALL DEPARTMENTAL TOOL ROOMS, MACHINE SHOP OF ALFRED HERBERT, LTD., COVENTRY, ENGLAND.

Equipped with lathe, universal grinder, large and small cutter grinders, gear-cutter grinder, large and small twist-drill grinder. All taps, drills, arbors, limit gauges, etc., are kept here and given out on checks; the revolving check board is seen in the middle of the room. The departmental system is devised to keep the tools for each class of work as near as possible to the workmen using them.

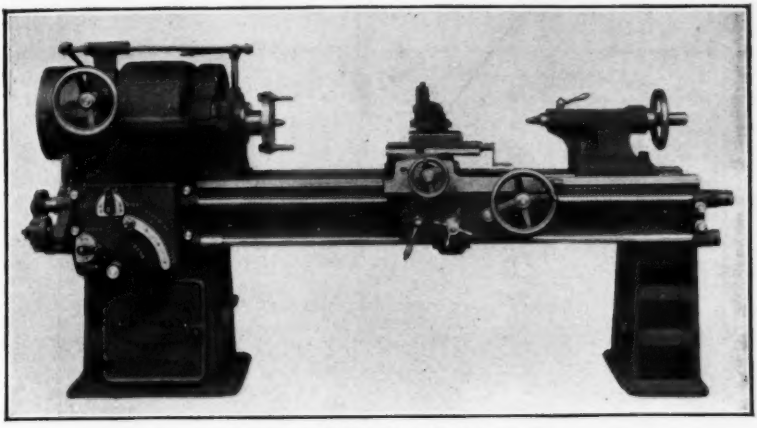
1.—High-class light lathes of from 6 inch to 8 inch centres, fully equipped with jaw chucks, driving and face plates, stationary and traveling steadies, taper- and former-turning attachment upon the rear of the machine, change wheels, traverse shaft, and an accurate leading screw. On page 527 is shown Lang's most recent lathe with self-contained speed-regulating gear and no countershaft needed.

2.—A larger lathe of about 10-inch centres with a gap is also very useful for swinging jigs, especially so if it also has a fairly long bed so that it may be used for boring bars, coneing out drilling-machine spindles, etc., under repair.



SHAPERS ADAPTED TO THE REQUIREMENTS OF TOOL-ROOM USE.

That on the left is a 16-inch motor-driven crank shaper by the Stockbridge Machine Co., Worcester, Mass. The novel belt drive, which secures almost the positiveness of a chain drive, is noteworthy. On the right is shown a 15-inch universal shaper by the Potter & Johnson Co., Pawtucket, R. I. It has power-driven feed on any angle with ten changes of speed, automatic feed stop, swivel table with auxiliary tilting side for compound angles; feed screws have graduated collars for fine adjustments.



A LATHE SUITABLE FOR TOOL-ROOM USE.

With variable speed drive. Made by John Lang & Sons, Johnstone, Scotland.

3.—Where much heavy milling is done, necessitating form cutters, a relieving lathe of the Reinecker type is a good machine to have in the tool room, although if small formed cutters only are used they may be done by such an adaption as is fitted to the Hendey-Norton lathe for this purpose. See page 530.

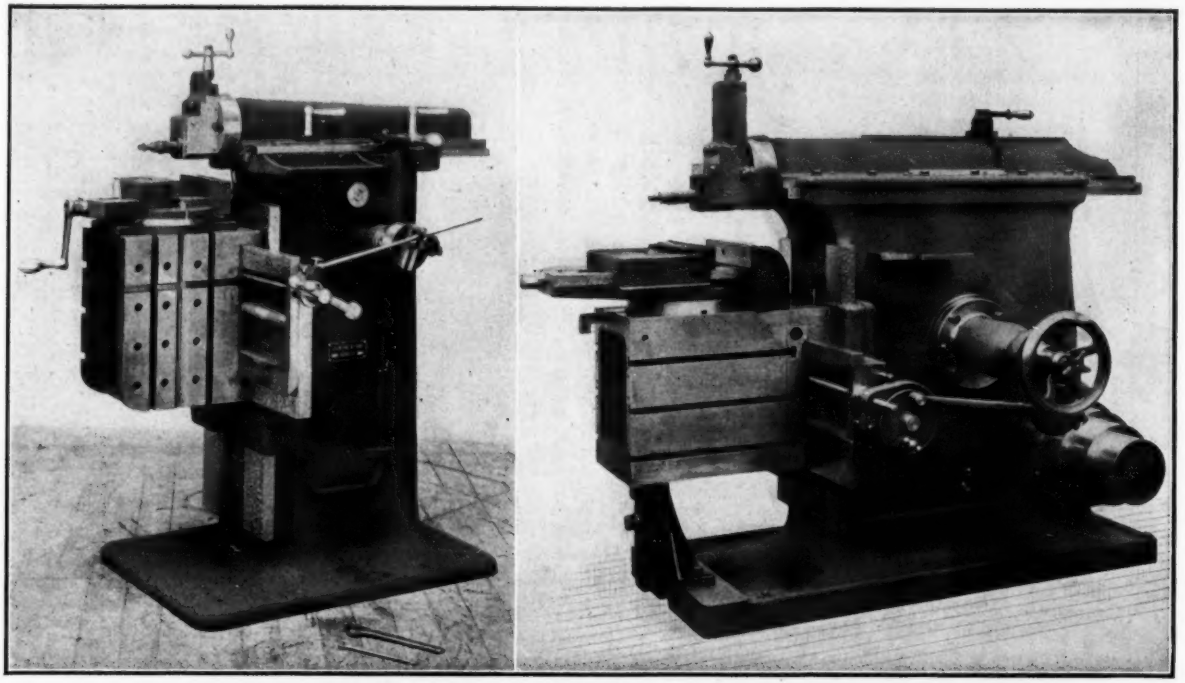
4.—One or more rack-geared shaping machines of from 24-inch to 30-inch stroke, giving a constant cutting speed with quick return, will also be necessary. Such a machine by Ludwig Loewe & Co. is illustrated on page 528.

5.—If much large jig work has to be done, a planer of suitable size might be wanted; but it would be unwise to put one down unless there were a probability of sufficient work to keep it occupied.

6.—In a small tool room, one vertical drilling machine will be wanted, of the "Standard" type with graduated sleeve, back gear, rise and fall spindle bracket, and a two-speed countershaft giving a range of speeds suiting it for drilling and also for boring with bar and cutters. Unless there is such a countershaft giving the two speeds, much boring work necessary on jigs becomes very awkward.

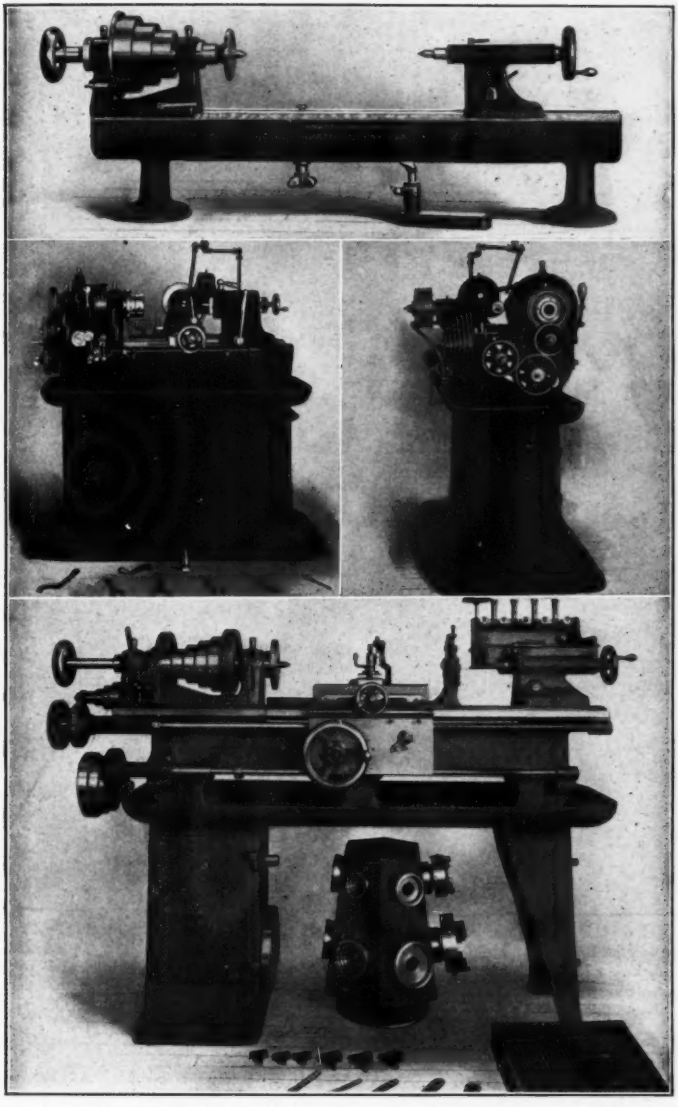
7.—A small universal radial drill will be very useful in a larger tool room, but with such a machine it would be well to have a flying stay for the arm to prevent lift when accurate jig boring is being done.

8.—An absolutely indispensable tool for tool room use is a universal back-geared milling machine fully provided with all auxiliaries, such as:—A pair of dividing heads fitted with both centres and self-centering chuck; a machine vise that may be angled in either direction;

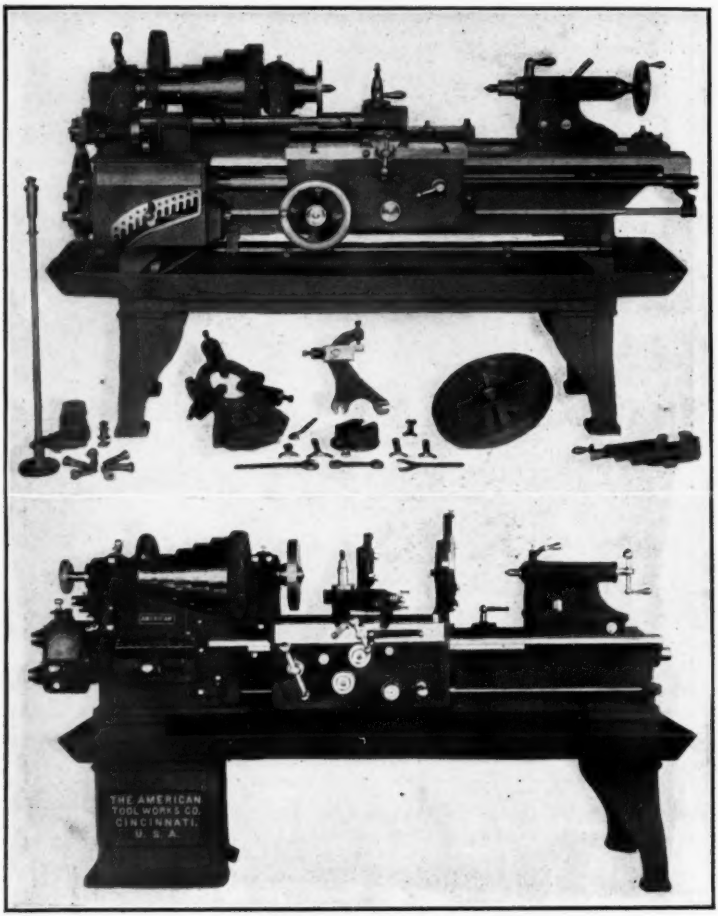


SHAPERS ADAPTED TO THE REQUIREMENTS OF TOOL-ROOM USE.

On the left is a rack-geared shaper by Ludwig Loewe & Co., of Berlin; on the right a shaper by the American Tool Works Co., of Cincinnati, Ohio.



SOME TOOL-ROOM EQUIPMENT FROM THE PRATT & WHITNEY CO., HARTFORD, CONN.
At the top is a 7 by 32-inch bench lathe; next, the front and end views of a 6 by 14-inch thread milling machine; at the bottom, a 10-inch by 5-foot toolmaker's lathe.

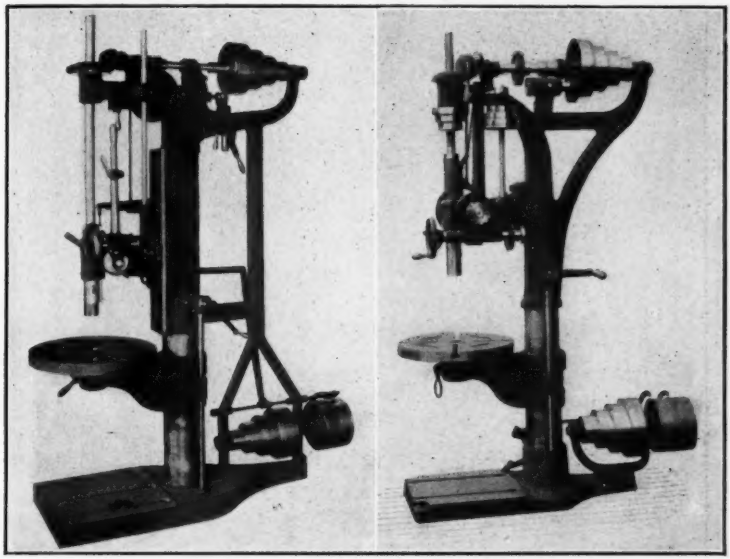


EXAMPLES OF TOOL-ROOM LATHES.

The one above is a Hendey-Norton 16-inch swing, made any length of bed, with relieving attachment for automatically backing off clearance on the teeth of hobs, mills, and forming cutters. It has a range of 2 to 26 divisions and may be set at any angle up to 30 degrees for backing off the sides of teeth. The lower figure shows a 16-inch engine lathe with pan, draw-in collet, and chuck, by the American Tool Works Co., Cincinnati, Ohio.

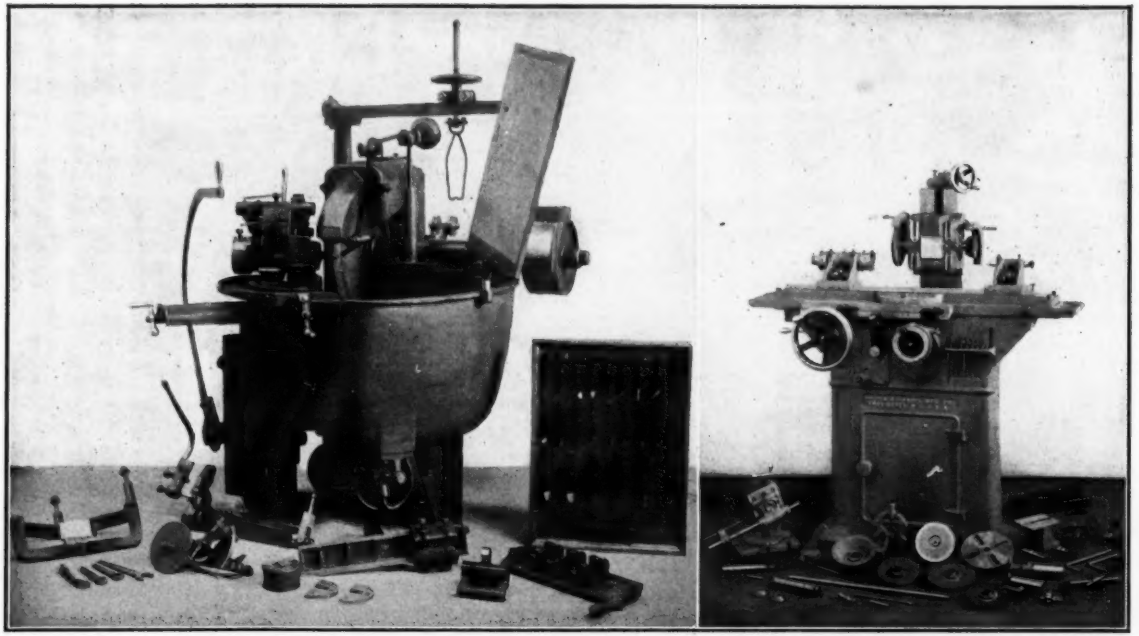
and supports for work, together with a full range of cutters and arbors. In a large tool room, of course, further milling machines will be wanted, but they need not be universal. Perhaps a plain horizontal machine, and also (in cases where pattern or die work has to be done) a vertical spindle mill, will be of very great service.

We now come to the final, and what perhaps might be considered the most important, tool equipment for this department, namely, the grinding machines and appliances.



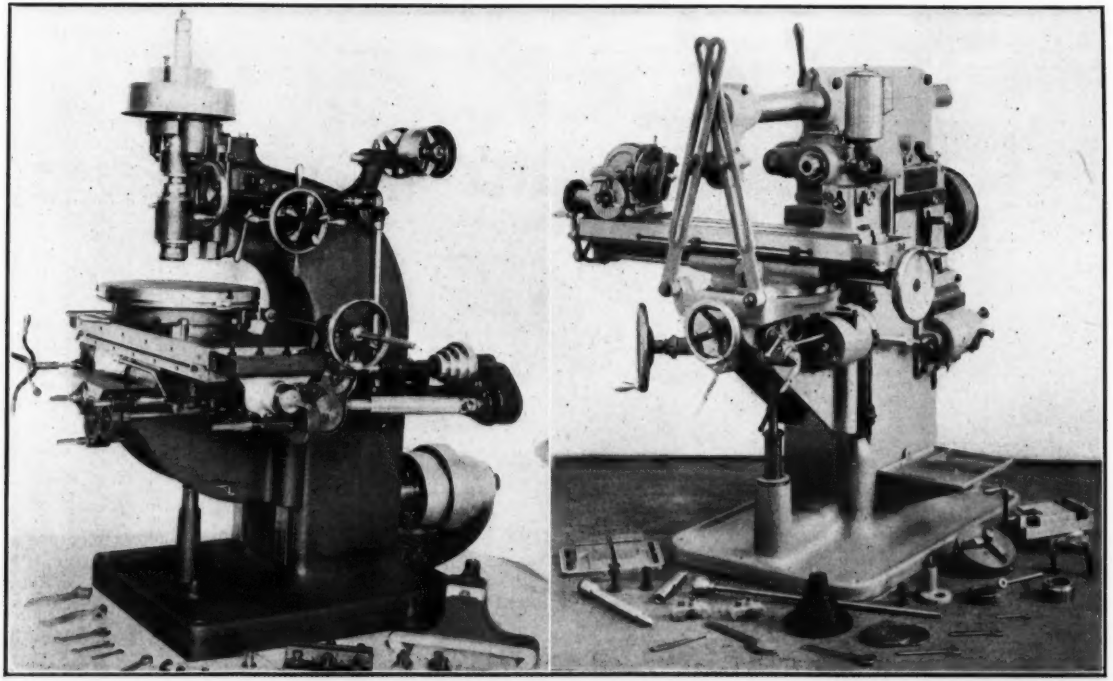
TYPES OF DRILLS FOR TOOL-ROOM USE.
On the left is a 26-inch drill with back gear, positive self feed, and automatic stop, by W. F. & John Barnes Co., Rockford, Ill. On the right is a drill made by the American Tool Works Co., Cincinnati, Ohio.

For the preparation of simple tools for turning, shaping, etc., a grinding machine such as the Sellers or the Gisholt will be almost indispensable. For the grinding of milling cutters a good form of cutter grinder will be required, and this should preferably be of the so-called universal type, that it may be used for any kind of cutter or reamer and also for the small work such as bushes and arbors. For general grinding work a good universal grinder will be needed, and this should, by preference, be large enough to take both lathe and drilling-machine spindles up to moderate sizes, in order to grind their journals when under repair. It should of course be fitted with the various appliances for all classes of work, including internal grinding, face grinding upon thin discs (for which a magnetic chuck is desirable) and also it should have draw-back arrangements for working either a collect chuck or a face-plate attachment. Of this kind of machine I prefer a design in which the emery wheel has as little movement as possible, beyond its own rotation, excepting for the pur-



EXAMPLES OF TOOL AND UNIVERSAL GRINDING MACHINES.

On the left is a tool-grinding machine made by Wm. Sellers & Co., Philadelphia. It is shown as equipped with a model board and instruction sheet. On the right is a Brown & Sharpe grinding machine, designed to meet the requirements of the tool room in the grinding of milling and formed cutters, beveled cutters, straddle and face mills, reamers, etc., and also for cylindrical grinding.

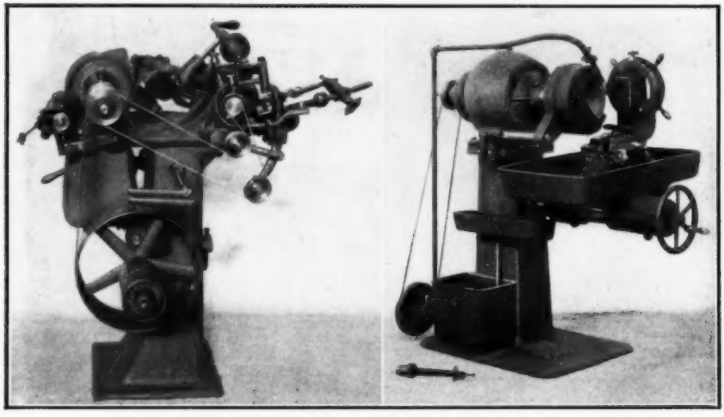


MILLING MACHINES FOR THE TOOL EQUIPMENT OF THE TOOL ROOM.

On the left is a vertical milling machine by the Becker-Brainard Milling Machine Co., Hyde Park, Mass. It has power feed to rotary and longitudinal feed to table. The cutter works in plain sight and the easy handling of the work table adapts the machine to irregular work. On the right is a 23 by 7½ by 17½ universal milling machine by the Brown & Sharpe Co., Providence, R. I. It is adapted to constant-speed motor drive, with hand or power vertical feed.

pose of feeding; for it is my experience that the firmer the headstock and the more rigid its connections, the higher is the quality of the work produced. The Brown & Sharpe machine, page 532, is a good machine for the work.

Another necessary machine is a twist-drill grinder, and this should advisably have a flow of water upon the stone and also a point-thinning attachment. Many of the machines for this purpose which are upon the market are very unsatisfactory in use, the general fault being the extreme difficulty in obtaining cutting lips of exactly equal length. Most of the machines aim at giving a correct angle and sufficient "backing off," but the most important requisition—namely, equal length of cutting lip—depends entirely upon the care and skill of the operator.

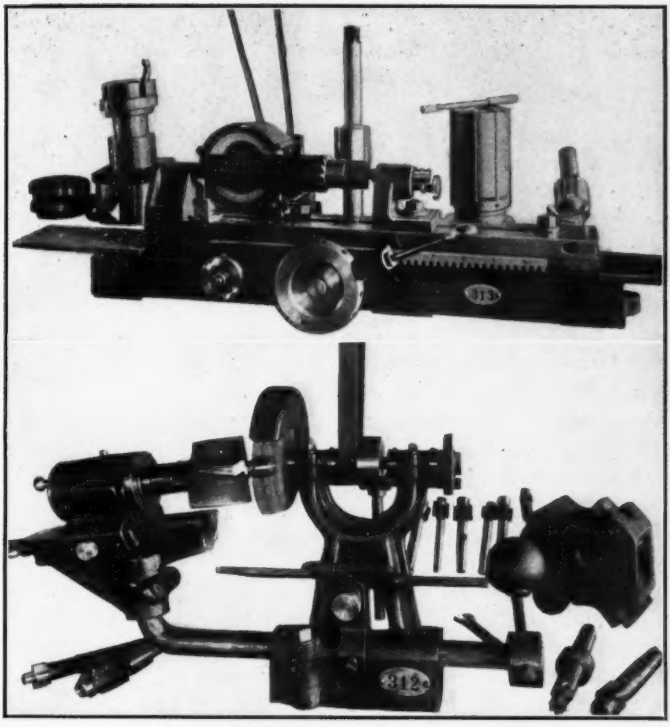


GRINDING MACHINES FOR TOOL-ROOM USE.

On the left is a drill-grinding and pointing machine made by Wm. Sellers & Co., Philadelphia. On the right, a tool grinder by the Gisholt Machine Co., Madison, Wis. A tool held in the tool holder may be moved about four different centers.

The machine-tool equipment of the tool room, if of small size, would now be completed with the addition of a small sensitive drill, a centring machine, a hack saw, a touching-up stone, and an arbor press. With such equipment as that described, together with accommodation for ten or twelve fitters, the tool room would be sufficient for a factory employing about five hundred hands, engaged upon general machine work, steam or gas engines. In establishments manufacturing machinery requiring large quantities of small detail work, the tool department would be larger in proportion, as would also be the case where much stamping or press work has to be done.

An initial small-tool kit purely for tool-room use is the next point



TOOL-GRINDING APPLIANCES DESIGNED BY THE BULLARD MACHINE TOOL COMPANY FOR THEIR OWN SHOP.

Above is a special grinder for straight and taper reamers. It uses an India corundum wheel, and it is not necessary to stone the reamers by hand afterward. The lower figure shows a special counterbore-grinding machine, which being used only for counter-bores does not require resetting for each job.

for consideration, and for this we must of necessity start with standards of measurement. A series of plug and ring gauges from 1/4 to 4 inches, ranging by 1/16 inch to 2 inches and by 1/8 inch beyond that, are of course necessary, although possibly some would find it sufficient to range by 1/16 inch to 1 inch, by 1/8 inch to 2 inches, and by 1/4 inch above that.

In addition to these, a set of standard end measuring blocks from 1/16 inch to 4 inches will be found extremely useful. For measurements above 4 inches, measuring rods rising by 1/2 inch up to such length as the needs of the establishment may indicate, will probably be required. These may be used in conjunction with either a measuring machine or a vernier to get any dimension wanted. A set of standard snap gauges from 1/4 inch up to 8 inches or 10 inches

would be found to be in frequent demand for tool-room use, and if these are supplemented with some taper gauges, such as Morse or Brown and Sharpe, the initial equipment of plain standards will be complete.

With regard to screw gauges:—perhaps the most satisfactory provision to make in this direction by way of standards, is to have a set of standard screw plugs for reference only, and to provide adjustable screw gauges instead of solid screwed rings, so that they may be set to the plugs from time to time in order to compensate for wear. Solid screwed ring gauges are apt to be unsatisfactory in use, as they must be soft, and it is so very easy to force them that in quite a short time, perhaps a few weeks, they would be unfit for use as standards. Plugs cannot be forced in this way so easily; thus they will retain their size more accurately and form a reasonable standard from which to work.

The small-tool kit will be completed when screwing tackle, solid and adjustable reamers, mandrels, outside and inside micrometers, etc., have been added to the list. Limit gauges are quite the right things to provide for general manufacturing purposes, but unless the limits are made extremely small, they can scarcely be considered suitable for the production of fine tools.

The Functions of the Tool Room.—Speaking in a broad sense, the prime function of the tool room is to act in the capacity of an arsenal to provide the management with the necessary weapons to wage war upon excessive cost. The word excessive is here used to indicate any excess of cost beyond that minimum at which it is possible to produce the articles to be manufactured.

The cost is bound to be in excess:—

1.—If the producing machines of the factory are not properly tooled.

2.—If the small tools are not kept in a proper state of repair.

3.—If the gauges and measuring appliances for shop use are not kept within the necessary degree of accuracy.

4.—If the tools provided are not ready for use.

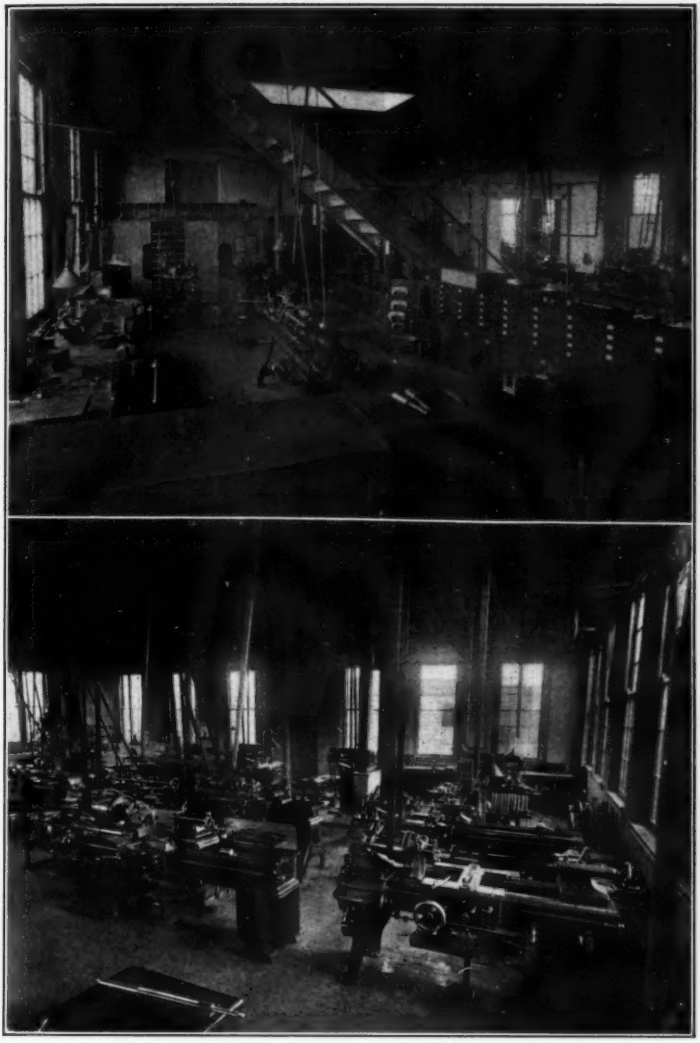
5.—If they cannot be found when required.

6.—If they are not actually used upon the jobs for which they have been prepared.

7.—If the producing machinery is not kept in an efficient state of repair.

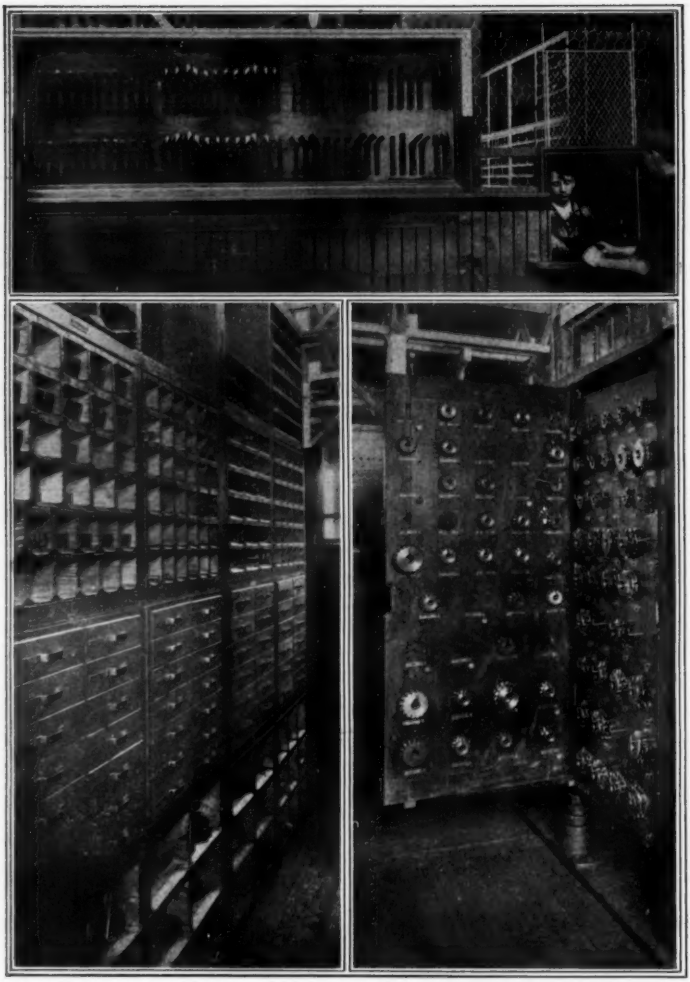
Hence the functions of the tool room may be said to embrace these several requirements.

The efficient fulfilment of the several functions mentioned will depend:—



TOOL ROOM OF THE CINCINNATI MILLING MACHINE CO., CINCINNATI, OHIO.

In the tool-making department, shown in the lower picture, all special tools are made on requisition from department head signed by general foreman or superintendent. In the tool storage (20 by 60) seen above, small tools are arranged in the drawer cabinets and closets seen at the right and across the foreground. A card index gives the closet, drawer, or shelf number of each tool or jig. Each foreman has a man (tool carrier) whose business it is to have all tools and jigs ready for each operator starting a job. He gets the list from a blue print handed him by the foreman when he specifies the next job for any workman.



FEATURES OF THE TOOL-ROOM SYSTEM OF THE LINK-BELT ENGINEERING COMPANY, PHILA.

At the top is shown the model board, carrying cast-iron models of all standard lathe tools. The workman consults this and orders the required tool by four-letter symbols. Below on the left is the storage for twist drills, sectional dies, large milling cutters, lathe tools, etc. Main racks are in large multiples of the same size, and interior racks in multiples suited to the large racks. Twist drills up to 1½ inch are kept in the drawers. The workman's check is placed on a peg in front of the pigeon hole, or in a pocket in the drawer. Tools are classified under mnemonic symbols. On the right is shown one of the sets of multiple doors, six to a set, upon which are hung milling cutters, gear cutters, solid dies, etc. This system, illustrated further on page 547, was installed by Messrs. Dodge & Day.

First; upon the method of storing and keeping track of tools.

Second; upon the system of marking the tools and appliances.

Third; upon the means provided for indicating to the workmen in the shops the tools that are to be used upon the jobs they may have in hand.

The first item, that of storing tools, is covered by the method of working the tool stores.

The conditions to be met by the system of storage are briefly as follows:—

(a) It should be simple and not too expensive.

(b) It should be readily expansible.

(c) It should provide a place for every tool it has to accommodate, which place should be strictly reserved for its particular tool and be identified with it.

(d) It should provide a ready means for indicating where any tool is when not in store.

(e) It should show what tools any man has in his possession at any time.

Probably as cheap a method of storage as any that could be devised is by an arrangement of pigeon holes, but it fails on several of the more important points. I have found by experience that any one system of storage will not cover, or rather accommodate, all types of tools and gauges for which provision must be made, and I therefore put forward three methods that have been found most useful.

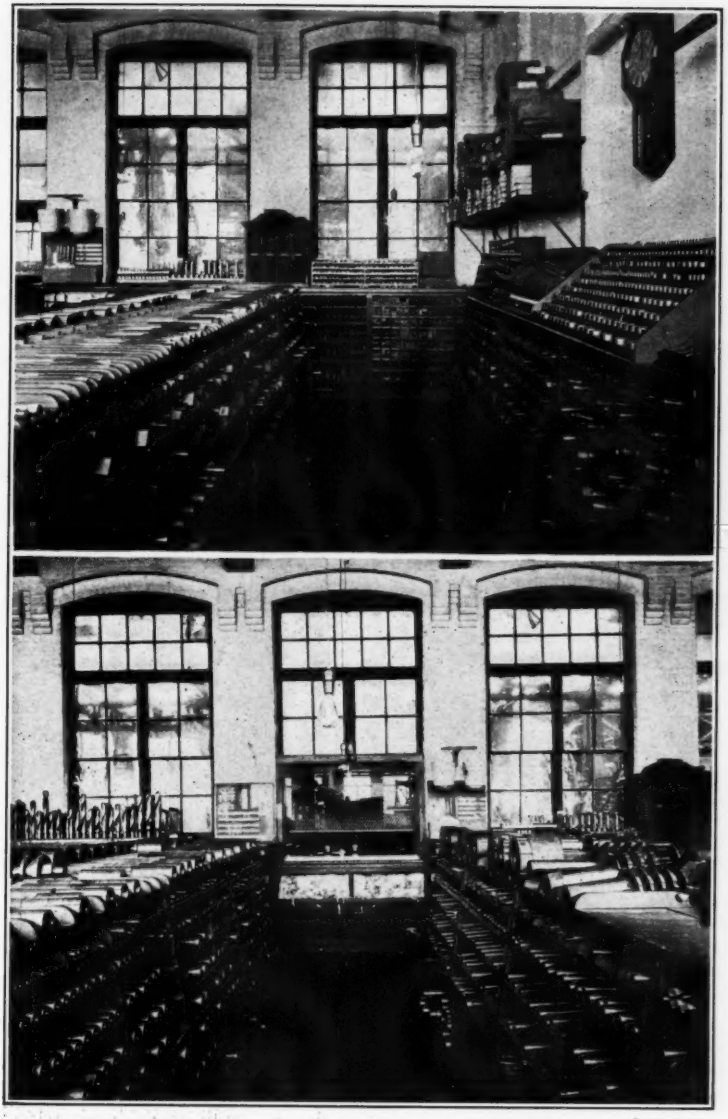
The Tray System.—An arrangement of pigeon holes that may be adjusted vertically may provide a means of storage that is economical in the matter of space, and to this the tray system may be likened, with the additional advantage that the portion of the pigeon hole upon which the tools rest may be drawn forward as though it were a drawer.

The storage space is provided by forming a series of vertical partitions from timbering about 1 inch thick and 15 or 16 inches apart, with a depth from 28 to 30 inches. These partitions should be carefully set at the right distance from each other so that the trays may interchange between the several bays so formed. The trays themselves are built up with two side strips of hard wood about 1½ to 2 inches broad and ¾ or ⅞ inch thick. These hard-wood pieces are grooved, and form clamps for the central portion of the tray, which is made of softer material with the grain running in the direction of the width of the tray. The central portion does not need to extend more than 24 inches from front to back, which allows the hard-wood sides to project beyond the central portion to the rear. Runners of

TOOL-STORAGE ROOM, SHOWING METHOD OF CARING FOR ARBORS, GAUGES, ETC., IN THE SHOPS OF THE BULLARD MACHINE-TOOL CO., BRIDGEPORT, CONN., U. S. A.

hard wood about ½ inch thick and 1½ inches broad are screwed to the partitions, two each above and below the tray, to form grooves in which it may slide.

When initially preparing the arrangement a quantity of trays should be made together with a corresponding number of strips, so that they may be fitted in place as required. The surface of the tray is provided with strips of wood nailed on, or blocks shaped to receive the various tools, grouping them to make the most of the space. The distance from tray to tray is made as small as is possible while accommodating the tools placed upon them. The illustration shown just



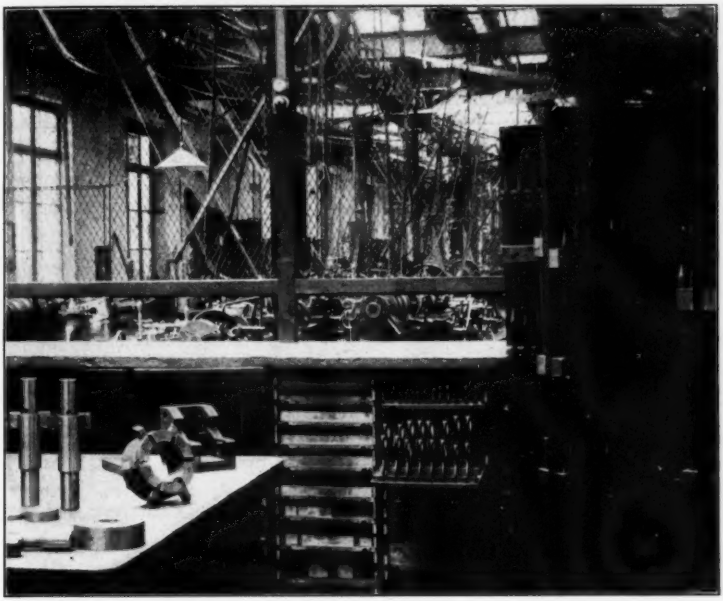
TOOL-STORAGE, POND MACHINE TOOL WORKS OF THE NILES-BEMENT-POND CO.

CABINET FOR TOOLS ARRANGED ON THE TRAY SYSTEM OF STORAGE, IN THE TOOL STORES OF MESSRS. BROWETT, LINDLEY & CO., PATRICROFT, MANCHESTER, ENGLAND.

above will assist to make clear the explanation of this most excellent method of storing small tools; more of these trays may be seen beneath the bench on page 543. Upon consideration it will be found to satisfy the conditions enumerated, for it is simple, cheap, expansible, and tidy in appearance.

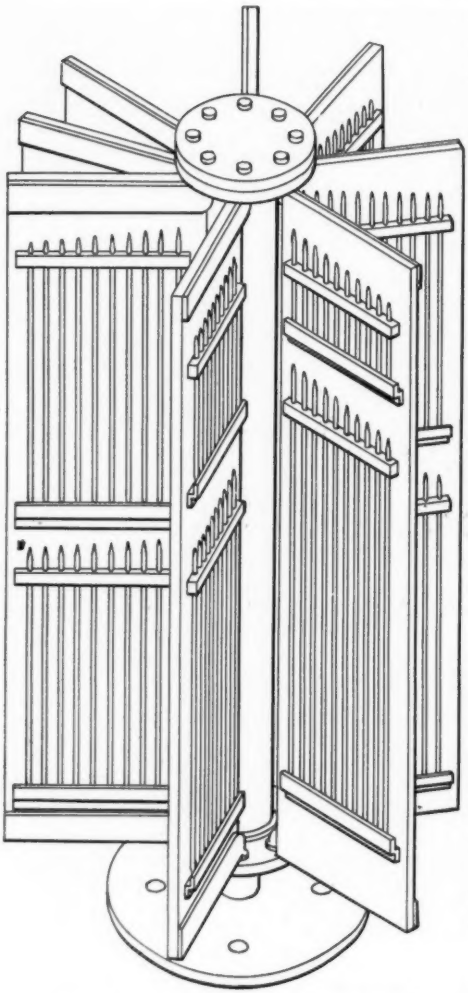
The Leaf System.—Some articles that require to be stored, while

of reasonably small diameter, are too long to be accommodated by trays. Take, for instance, bar or point gauges, long cutter bars, and other tools of like nature. For the storage of such as these, what I have styled the "Leaf System" is as simple in its way as the tray arrangement. It consists of a series of clamped boards about 20 inches wide, ¾ inch thick, and 4 to 6 feet high. These boards are hinged in convenient positions in a similar manner to a door, and upon their sides places are provided to receive the long tools mentioned. This arrangement can be seen to the right of the picture below and in more detail in the drawing reproduced on page 544.



CORNER OF TOOL STORES AT THE WORKS OF MESSRS. BROWETT, LINDLEY & CO., SHOWING THE TRAY AND LEAF METHODS OF STORAGE.

A simple method of arranging a series of leaves of this kind is to take a piece of stout gas pipe about 2 to 2½ inches in diameter, and longer by an inch or so than the leaves to be accommodated. Flanges are fitted to the upper and lower extremities, and they in turn have a number of holes drilled in them to receive strong pivots forming hinges that are attached to the leaves. The upper end of the pipe is fitted with a screwed plug and the whole is dropped over a second pipe or pillar which is pointed at its upper end to form a pivot, while its lower end is firmly secured to the floor by a large flange. This de-



REVOLVING TOOL RACK FOR "LEAF SYSTEM."

tailed construction is clearly shown on page 546.

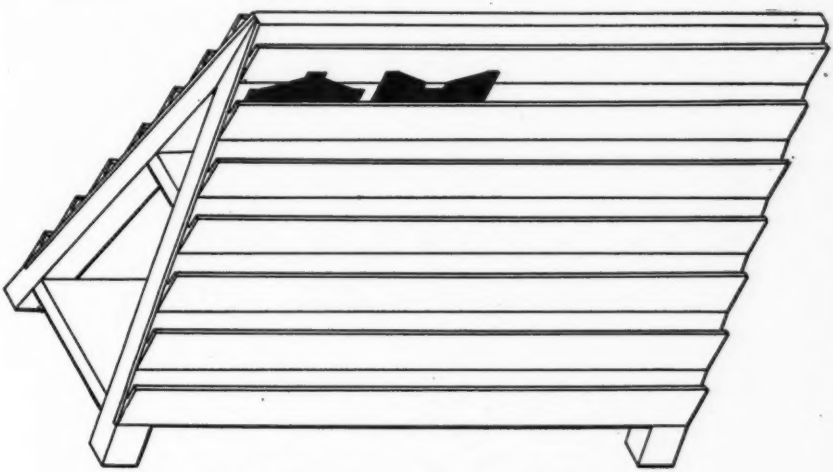
Such an arrangement as this will accommodate eight or ten leaves, each of which is readily accessible, as the whole is upon a revolving stand.

The "Letter-Rack" system.—In engine shops it is frequently necessary to prepare sheet-iron gauges giving the shapes of such things as conical pistons, cylinder covers, etc., and these are apt to be somewhat awkward to store in an accessible position without occupying too much space. For this purpose I have found a kind of large letter-rack with double sides standing upon the floor, and about 5 feet 6 inches high to be very useful. This arrangement will be better understood by reference to a sketch on the facing page.

The three systems of storage mentioned will probably be found to accommodate the bulk of the small tools and jigs that need to be kept in a tool stores. It will be observed that the arrangements described cover the first four conditions that require to be met by the systems of storage, so we now have to show how the remaining conditions may be filled.

Any means of indicating where a tool has been taken, by a process of booking either upon slates, boards, or in books, will be found too

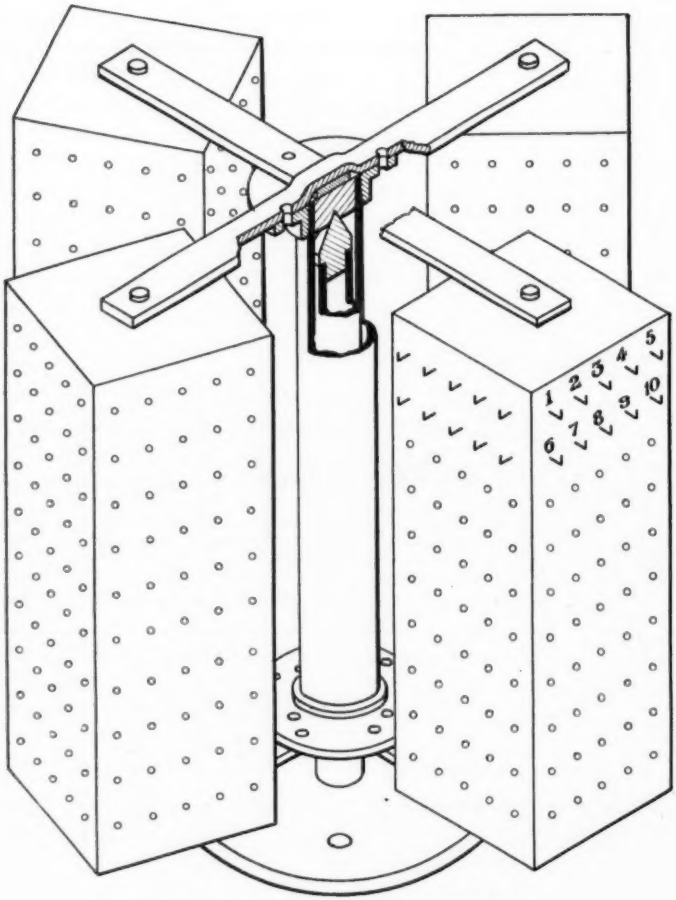
clumsy for general use. A very satisfactory plan is to provide a number of metal checks stamped with the numbers by which the men are identified, say about eight or ten for each man. When a tool is given out from stores, one of these checks bearing the man's number is to be placed in the position from which the tool has been taken. The man is then known to possess that tool so long as his check there remains, and he is held responsible for its safe keeping. Some firms will give the checks into the hands of the men themselves, making them responsible for their safety, and for all tools obtained from stores with them. Thus if a man loses a check and another finding it should obtain a tool from stores by its aid, the man whose number is upon the check is held responsible. When this arrangement is followed a periodic inspection of checks must be made.



RACK FOR SHEET GAUGES, LETTER-RACK TYPE.

A better method is to provide for these checks to be kept within the stores upon a hook representing the man's number. Where a large number of checks have to be carried, such a fitting as that illustrated on the following page is very convenient.

In order to fulfill the last condition, it is necessary to have still another series of checks, somewhat larger and differing in shape, so that upon each may be stamped the name or other means of identifying a tool. One such check is marked for each tool and is kept with it upon its tray or leaf. When a workman obtains a tool the procedure then becomes for the stores keeper to take a numbered check off the man's hook, placing it in the position from which the tool is taken, and



REVOLVING CHECK STAND FOR TOOL-ROOM USE.

at the same time the check corresponding to the tool is placed upon the man's hook. This double checking may be used for an additional purpose, for by its aid every week end the stores keeper can see and note what tools have not been returned to store, and at the same time state by whom the tool was obtained. It is a good plan to require that all tools should be returned to store before wages are paid, the stores keeper informing the cashier what men have broken the rule, a few minutes before pay time, and the cashier will then withhold the man's wages until the tool is found and taken to stores.

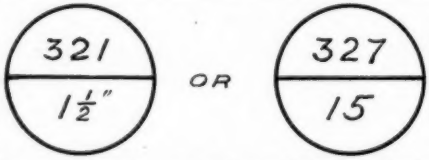
Returning once more to the functions of the tool room, it has been stated that their efficient fulfillment depends also upon the system of marking and the means for indicating to the workmen the tools to be used. These two things are very closely associated, because the marking of the tool is a means of identification and the tools to be used must be indicated upon the drawing to which the man works, unless dependence is to be placed upon memories of the men and foremen. The means of identification must be some system of numbering to avoid clumsiness, and moreover, it should simultaneously indicate the location, as thereby the storekeeper is assisted in finding the tool.

To operate a tool room satisfactorily at least one draughtsman should be associated with it, and he should keep a register of all tools

MANDREL RACK, TOOL STORES OF THE LINK BELT ENGINEERING CO., NICETOWN, PHILADELPHIA.

Each mandrel has its special place, marked with the size on the round brass plate. When a mandrel is delivered to a workman, the man's check is hung upon the corresponding hook. The circular form of the hook secures the check against all danger of dropping or being brushed off.

that are made. He should control in large measure the locating of tools in the stores, so that similar tools either actually made or anticipated may be grouped together and numbered by their sizes. When using the tray system it will be found convenient to number each tray and to number independently each tool upon the tray. Thus ordinary tools, such as taps, reamers, gauges, etc., may be considered to be numbered by their size, and other tools whose size cannot be so used may be plainly numbered. The full tool identification mark may then be such as follows:—



The interpretation of the symbol as is shown at the left. The number above the bar within the circle indicates the tray, leaf, pigeon hole, drawer, or place where the tool is kept, and the number below gives the size or number of the actual tool of the group upon the tray.

It would be part of the natural duties of the draughtsman above referred to, to mark upon each drawing of work to be made, before it is issued to the shops, the tool identification marks.

This provides another precaution—that tools are actually made suitable for the job—for should the draughtsman find no suitable tool to be in existence, he would prepare a sketch and have one made in readiness, issuing with the sketch the marks to be placed upon the tool when made.

A scheme of operations based upon the suggestions contained in this article will be found to make a tool room fulfill its various functions and become a live, active, and indispensable part of the establishment, and not the least valuable point is that brought out at the conclusion; for it secures the much needed connection between the draughting office, tool room, and the workman.

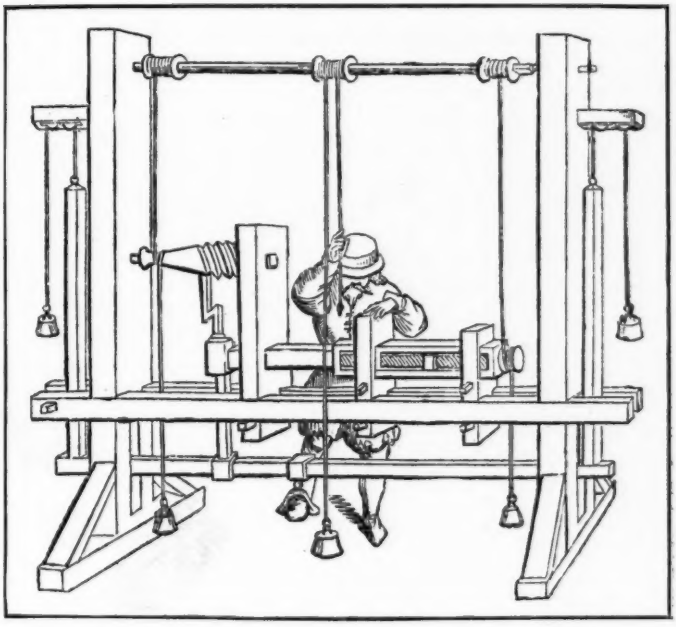


FIG. I. SCREW-CUTTING LATHE BUILT IN FRANCE IN 1659.

ADVANCED PRACTICE IN ECONOMICAL METAL CUTTING.

By Charles Day.

One of the most experienced shop managers of the time says machine-shop practice is changing so fast that "the workman of the year 1900, if kept out of touch with current developments, would make a poorer showing in the shop of 1915 than the workman of George Stephenson's time would in the average shop of today." Mr. Day reviews concisely the great factors of this change. A detailed discussion of their practical bearings, by Mr. Hess, will form an important feature of THE ENGINEERING MAGAZINE for some months to come.—THE EDITORS.

DURING the past few years we have heard much of the high-speed steels, modern machine equipment, and motor drive, and there is no longer any doubt as to their great value as a means of reducing cost and extending manufacture. The desired results can be attained, however, only when the equipment is in the hands of those who fully realize its possibilities and the relation that each factor bears to the problem as a whole.

The modern machine shop implies more than buildings and machinery, as the labor conditions and system of shop management in use influence the type of equipment and govern the efficiency that may be attained. At present, growth is so rapid that the only way thoroughly original and valuable results may be reached is by concentrating on a single detail, studying its relation to all other factors and, by persistent investigation and thought, arriving at the true facts. A general knowledge, however, is of great value to the worker in assisting him to see the true bearing of the specialty upon which his energies are being expended.

We must ever bear in mind that the machine shop in all its details is but a means to an end, and the general problem starts with the first conception of the article to be manufactured. The value to the designer of a thorough knowledge of shop practice cannot be over-estimated, for while the efficient plant can perform *operations* at a minimum cost, the aggregate cost of a job depends on the amount and character of the machining.

The high-speed steel, rapid-reduction lathe, and motor drive, cannot be intelligently considered separately, nor should a plant be designed and equipped without knowledge of the type of management to be employed. Rather than describe only modern equipment, I will first briefly outline the historical development of machine-shop apparatus, for it is only in the light of this information that we can have a full realization of the modern shop.

A most interesting lecture by Mr. H. F. J. Porter, on the "History of the Art of Forging," outlines this most important subject from its early beginning, about 3,000 years B. C., to the present day. In this connection, however, the work of Benjamin Huntsman, who labored more than one hundred and sixty years ago to produce a high-grade crucible steel, marks the first great step forward. Years were devoted by him to investigation and experiment, resulting in a crucible carbon steel which for many years held its own in point of quality and uniformity. Later, Messrs. Heath and Mushet, by the addition of manganese, produced a so-called air-hardening steel of greater efficiency, and the brand known as "Sheffield Mushet" held the foremost position as a high-speed steel of great uniformity until the discoveries made a few years ago by Messrs. Taylor and White at the Bethlehem Steel Works.

Those who have followed the growth of the machine shop during the past ten years, and, in addition, are familiar with its early history, find so many landmarks of almost epoch-making importance that it is difficult to say just when the greatest strides forward were made.

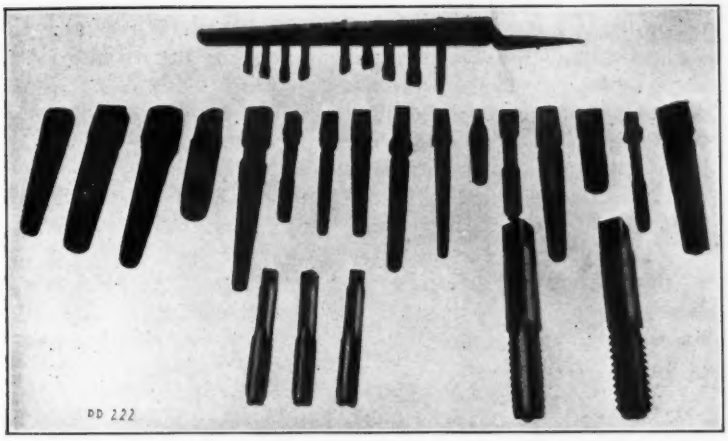


FIG. 2. COLLECTION OF TAPS, SHOWING EVOLUTION FROM THE OLDEST TO THE MOST MODERN TYPE.

As a result of the work of Taylor and White, however, the achievements of the modern shop are known to even those not directly engaged in this line, through the impetus received in all its details as a result of their invention. Intelligent direction of shop work has been the greatest lesson taught by Mr. Taylor, for no matter how great his discovery of the treatment of steel, that, in itself, is but secondary as compared with the indirect influence it has exerted in every branch of manufacture. It has awakened the engineering world to the possibilities of intelligent effort as opposed to slip-shod methods—an expression none too strong to describe conditions found on every hand a few years since.

Like most great discoveries, the Taylor-White process was the result of a most painstaking investigation, but can now be expressed in the simplest terms. The term "high-heat treatment" is probably used hundreds of times each day, but in the few years that have elapsed the pioneering work at the Bethlehem Steel Works has been forgotten by many. It is to Fred Taylor and his associate, Maunsel White—and to them primarily—that we are indebted for cutting tools that enable us to remove metal from two to three times as rapidly as was formerly possible. Taylor's work in shop management has been equally revolutionary although little understood by many. We can well say of his work, as Agassiz has said of Humboldt:—

> "The fertilizing power of a great mind is truly wonderful, but as we travel further from the source, it is hidden from us by the very abundance and productiveness it has caused."

Mr. William Fairbairn, in an address before the British Association of Manchester in 1861, stated that when he first became acquainted with mechanical engineering, about 1804, there were no self-acting tools; everything was executed by hand. There were neither planing, slotting, nor shaping machines; and the whole stock of an engineering or machine establishment might be summed up in a few lathes, drills, and boring machines of rude construction.

It will thus be seen that the year 1904 is quite near to the one hundredth anniversary of the first impetus given to the development of wood and metal-working machinery, which has resulted in the production today of apparatus such as the early pioneers never dreamed of. There are a number of men whose names are so closely associated with the development of the machine shop that I feel they should be mentioned here. The work of Savery and Newcomen

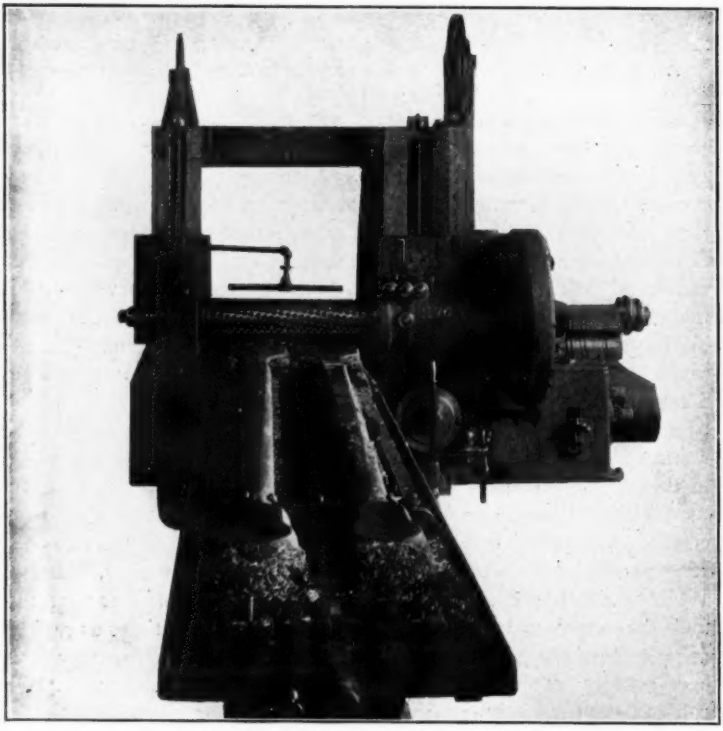


FIG. 3. A MODERN HEAVY MILLING MACHINE.

Horizontal-spindle milling machine for heaviest class of slabbing work, slabbing two large Corliss-engine connecting rods. Ingersoll Milling-Machine Co., Rockford, Ill.

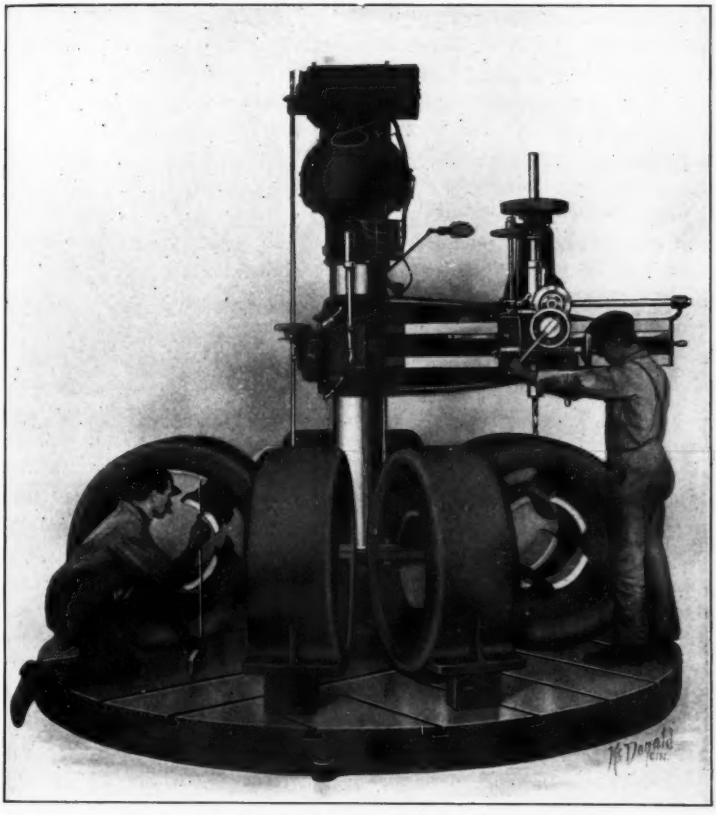


FIG. 4. AN EXAMPLE OF THE MULTIPLE SETTING BASE.
Bickford Drill & Tool Company's radial drill with circular base in the shops of the Crocker-Wheeler Co.

led up to that of James Watt; Murdock to the Stephensons'; and Maudslay to Clement, Roberts, Nasmyth, and Whitworth.

Watt's engine was so much in advance of the mechanical capabilities of the age that it could be manufactured only with the greatest difficulty. The cylinders, at the start, were not bored at all, and even after Watt became associated with Boulton and was assisted by the latter's best mechanics, the opinion was expressed by many that his engine would never be brought into practical use on account of the difficulty of getting its various parts manufactured with sufficient precision. It seem almost incredible to engineers of today that Watt should have had so few facilities at his command.

It is an interesting study of the subject of environment to trace the lives of the pioneers of machine-tool industry. In the workshop of Joseph Bramah was an apprentice—Henry Maudslay, born in 1771, to whom the machine shop of today owes more than any other of its founders. The invention of the slide rest on the lathe is now universally conceded to him, and, as a result of this, the other machine tools with which we are familiar were rapidly developed.

The lathe can be traced back many hundred years, one of the earliest types being shown at the Buffalo fair. A Mussulman squatted on the ground manipulating with astonishing dexterity this primitive machine but a few inches high—two stakes, a wedge adjusting the crude centres, one hand plying a bow to drive the work, with the foot acting as a rest and guide to the tool in the other hand. The slide rest, however, immediately revolutionized lathe work, not only assuring much greater accuracy than formerly, but reducing cost by making it possible to take heavier cuts. Like other great inventions, it had to encounter much ridicule; for a time it was spoken of as "Maudslay's go-cart"; but its advantages were so decided that it gradually became established. Very shortly after its invention, modifications of the lathe, the planer, slotter and numerous other tools came into use. Nearly all of the machines described below can, therefore, be traced to the workshops of the well-known firm of Maudslay, Field, & Company, established 1810.

The earliest screw lathe of which I have been able to find record bears date of 1659, and is illustrated in Figure 1. A practical machine for cutting screw threads was not developed, however, until Maudslay gave this matter his attention. Previous to his time screws were, for the most part, cut by hand, by means either of a file or a chisel, according to their size. Every bolt, with its corresponding nut, had, of course, to be marked, and the complications arising from this cause can readily be imagined. In Maudslay's system of screw-cutting machinery we have the foundation of all that has since been done in this important branch of machine construction, in which he was so ably followed by Joseph Clement and Joseph Whitworth.

To illustrate the crude condition of affairs existing but recently, I have had a photograph (Figure 2) made of a series of old taps that I have collected. The earliest types worked on the principle of the swage, and no means were provided for clearance or lubrication. Step by step the modern tap has been developed, nearly every intermediate step being illustrated. It was sometime before the swaging principle gave way to a cutting action, and it would, indeed, be hard to find a series of tools defining more clearly the evolution undergone

through a term of years. On the one hand we have the hand-made tool—simply a taper screw; on the other the modern stagger-tooth tap made by machinery to the greatest accuracy required.

Joseph Clement, in 1825, built one of the first planers, designed to handle work up to 6-feet square. Clement's work was ably followed by Whitworth, who established the British screw standard now in general use in England, as well as the micrometer and surface plate.

William Fairbairn, born in 1787, revolutionized the transmission of power by shafting. Square, cast-iron shafts were almost universally in use when he entered this field, as well as pulleys and boxes of the crudest character. To Mr. Fairbairn we owe our present system of shafting and pulleys, and the importance of his work in connection with the development of the machine and cotton industries can scarcely be over-estimated.

I have only attempted to touch upon the most important historical facts in connection with the development of machine-shop equipment. The rapid growth of this industry as a result of the work of those pioneers referred to is known to all, but in the years to come the present time will probably stand out clearly as the period of general awakening to the possibilities of intelligent work.

Previous to the investigation conducted by Mr. Fred W. Taylor, at the Bethlehem Steel Works, practically no data of value were available relative to the laws governing speed, feed, and depth of cut for different materials, nor have later investigators obtained results approaching his in so far as their usefulness is concerned.

Data of this kind considered strictly from the commercial side are of value only in so far is they lend themselves to the production of better machines, or the more efficient operation of those in use. Just as the machinist by means of the Warner cut meter can now know at all times the cutting speed as easily as he can tell the time of day from his watch, so the Taylor-Barth slide rules make the determination of cutting speed, depth of cut, etc., the simplest matter. Either problem could be worked out mathematically, but such calculations are not practicable in daily shop work.

There are numerous makes of tool steel upon the market of almost equal efficiency, and much better results would be obtained by the average shop if their characteristics were more clearly understood. The need of a high heat (that is, a heat at which the point of the tool can be readily nicked by pressure from a small iron rod), of care in grinding, proper provision for clamping at tool post, and finally, a knowledge as to the work the tool should be capable of, are fully appreciated by but few. Even today many shops permit their work-

men to grind their own tools, but this practice is unquestionably bad under any circumstances. This brings us to one of the most important factors in connection with the modern shop—I refer to the tool department, where the cutting tools of all kinds are not only cared for, but the jigs, templets and gauges designed and made. While economies that may result if parts are made in sufficient quantity are generally understood, there are a number of large concerns which still fail to appreciate what is being accomplished along these lines.

One of the most able shop managers, whose experience extends through the shops of the United States, Germany and Great Britain, says, in part:

> "Indeed, the essential of economic production next to the use of the best modern tools lies in the separation of the preparation and care of tools from their operation. A limited number of highly skilled and highly-paid tool makers should be entrusted with the care of the machines and the preparation and to the tending of machines. In this way the cost of the skilled labor is divided among so many machines as to form but a small element in production cost, and the great bulk of the labor which bears a direct relation to the product may be performed by cheaper men."

Mr. John Ashford's article appearing in this issue considers the tool room in detail. The model tools illustrated on page 538 placed alongside the tool-room window so that the workman can designate those he requires, are very necessary if the cutting tools are to be used to the best advantage. Much experimenting has been done to determine the best forging and grinding angles for various conditions of operation. In connection with the installation of the Taylor system of management in the shops of the Link-Belt Engineering Company, this matter has been gone into fully, Figure 5 being a photograph from one of our tracings and giving complete data relative to side-finishing tools. In this way each type of tool has been worked out, much experimenting being required to arrive at the necessary data. Many tools are forged under the steam hammer, bending being facilitated by dies designed for that purpose.

Time brings many changes, and success at one period very often results from radically different causes from those which produced success at another. One hundred years ago there were but a few competent machinists, and fewer establishments where good work could be done. The demand for steam engines and cotton machinery was great, so that such men as Maudslay, Clement, Nasmyth and Fairbairn could keep their shops busy even though their cost of production was extremely high. These men, however, were usually in the shop a greater part of their time, and personally superintended the

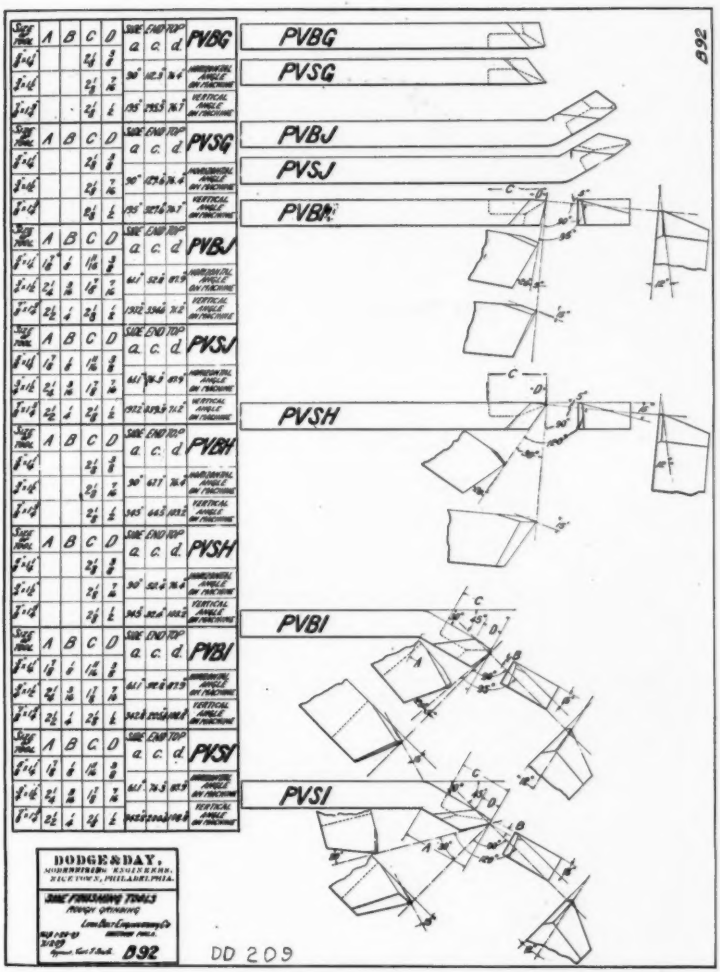
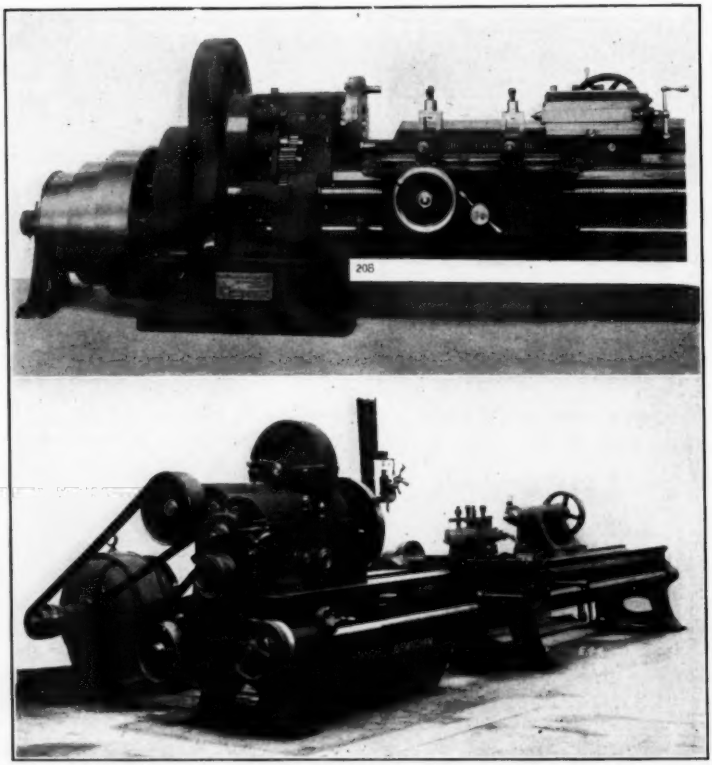


FIG. 5. AN ILLUSTRATION OF THE DEVELOPMENT OF SIDE-FINISHING TOOLS.

work of each man. But as machine tools came into general use, and could be readily obtained in the open market, competition began to play an important part, and the need of specializing was immediately felt. In this connection we do not have to go back many years, for it is clearly illustrated in the machine-tool business in the United States. Twenty-five years ago practically all the machine tools were made in New England, each manufacturer making, as a rule, all the



FIGS. 6 & 7. MODERN HIGH-SPEED LATHES. SHOWING STUDY OF RIGIDITY OF DESIGN, CONVENIENCE OF OPERATION, AND ADEQUATE POWER.

The upper one is a rapid reduction lathe by Lodge & Shipley, Cincinnati, Ohio. The lower is a modern motor-driven lathe by the Tangye Tool & Electrical Co., Birmingham, England.

various types of apparatus required by the average shop. Before long the need of specializing became apparent, as it was found impossible to manufacture at low cost unless a sufficient quantity of the same line of product were made. The machine-tool builders of the middle west started in business with a realization of this fact and designed their shops accordingly, concentrating all their energies on one type of tool. These specialized concerns are especially well equipped for building machines to meet the requirements of the modern steels.

After scientific investigation had evolved the high-speed tool it would be unreasonable to suppose that machines formerly in use would be fitted for this new duty. At first manufacturers were slow to realize the extent of modifications necessary, but within the past

two years their attitude has completely changed. We find in almost every issue of our technical papers machines of modified design suited for specific conditions. The manufacturer realizes that he must now adapt his machines to fulfil certain conditions at the tool, and the need of an experimental department to determine the characteristics of the latter is now generally conceded.

Enormous planers have recently been designed to take work up to 12-feet square through the housings. Think of the surprise of Joseph Clement if he could see such a machine, with a tool in each head, removing metal at the rate of possibly two or three tons an hour. Numerous schemes have been resorted to to do away with the troublesome shifting of belts, but so far they have not met with general adoption. I refer to the magnetic and pneumatic clutches which are now used in a number of shops. Many suppose that the modern steels cannot be operated at as high cutting speeds in a planer as on a lathe, but this is not the case. If the tool be prevented from dragging on the return the action is similar to that of a saw with inserted teeth. I have

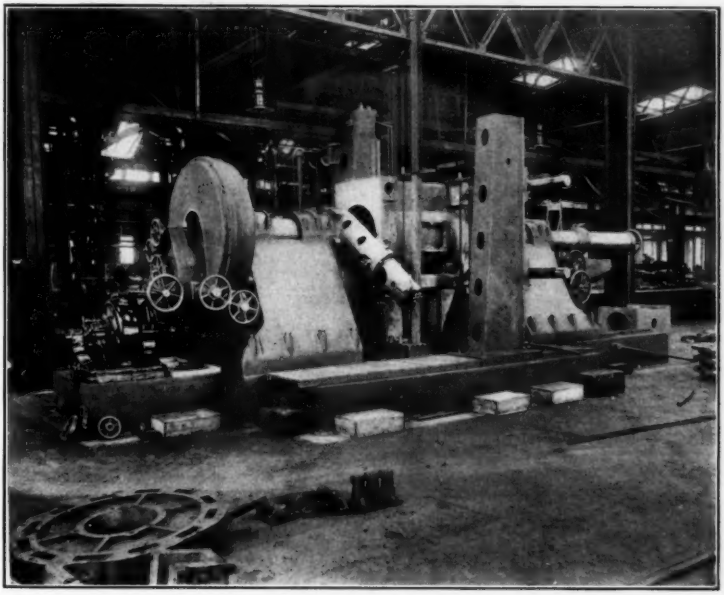
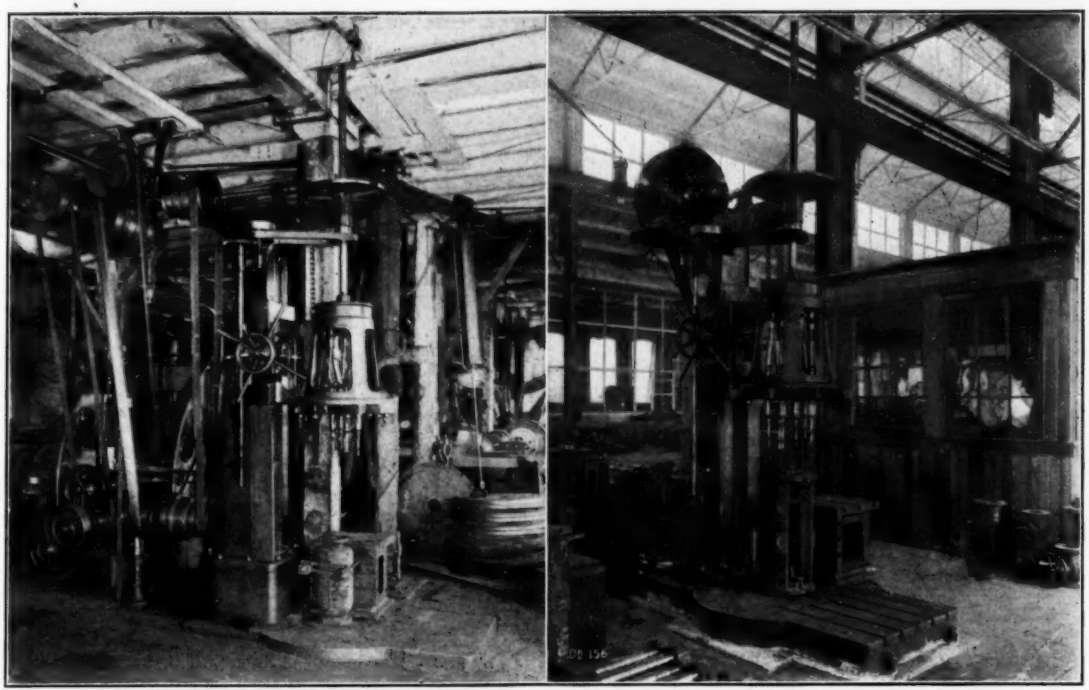


FIG. 8. CORLISS-CYLINDER-BORING MACHINE BUILT BY THE NILES-BEMENT-POND CO. AND INSTALLED IN THE SHOPS OF THE HOOVEN-OWENS-RENTSCHLER CO., HAMILTON, OHIO.

Bores the cylinders and valve ports and faces the flanges at one operation. Motor driven and very rugged in design, so as to use high-speed steels to the best advantage.



FIGS. 9 & 10. ILLUSTRATING INCREASE OF MACHINE-TOOL CAPABILITIES BY INTRODUCTION OF ELECTRIC DRIVING.

Bausch multiple-spindle drill; on the left, as operating in the old plant of the Jeanesville Iron Co., Jeanesville, Pa.; on the right, the same tool equipped with Crocker-Wheeler motor in the new shops of the company.

seen the Taylor-Newbold saws running at 260 feet cutting speed, with an advance of 8 inches per minute, cutting off steel bars (15 point carbon). Reversing a planer at high speeds is not an easy matter, although it is now being successfully accomplished.

More revolutionary measures have been necessary in connection with the design of milling and drilling machines, as milling cutters and twist drills have been made of air-hardened steel only since the discovery of the high-heat treatment, while for lathe work, the Mushet tool was an intermediate step between carbon and high-speed steels.

I recently had the pleasure of reviewing some tests made upon blue-chip milling cutters, by Wheelock & Lovejoy of Boston, and the great life of the tools in addition to the higher cutting speeds and feeds are remarkable. One form cutter used for milling hard, unannealed tool-steel forgings milled 9,900 pieces without injuring the cutting edge in the slightest degree. The carbon tool-steel cutter failed completely after machining 100 pieces.

One of the most important features in connection with the modern shop is the motor drive, which, in so many ways, has contributed to more economical manufacture. The first introduction of the motor into the machine shop was about 1883—but 20 years ago. It was estimated in January, 1903, that in the United States alone, the motors operating in manufacturing establishments would aggregate at least 350,000 horse-power, and this figure has grown so rapidly since that any estimate I might make would probably be wide of the mark.

Today there is no longer any question as to the desirability of electrical transmission in manufacturing establishments. It is only the details that are still open to discussion among engineers. To describe the various types of apparatus on the market, or enlarge on the numerous advantages that should follow their use would require a separate paper; but Figures 9 and 10 will serve to illustrate practically all the advantages of the motor drive, namely:—ease with which material may be handled on account of location of the machine under overhead crane; adequate power at all times; sufficient number and range of speeds; ease of operation, etc.

The Crocker-Wheeler Company were among the first concerns to realize fully the possibilities of the individual drive, and the apparatus which they have developed has been designed primarily to meet shop requirements. The motor also makes possible the use of the portable tool in a way that was not practicable before its adoption. Figure 11 illustrates a bed-plate in the works of the Westinghouse Electric & Mfg. Co., at Pittsburg, Pa., where a number of portable tools are at work on a dynamo field frame. A gang of men especially

trained in this line have charge of bolting down the work and machines, and as a number of tools can frequently be working on the same piece a marked saving of time is therefore effected.

Figure 12 shows an interior view of the main machine shop of the Jeanesville Iron Works Co., and illustrates the principal features of the modern shop, such as the overhead traveling electric crane, industrial railway, electric operation of machine tools, and the good natural light.

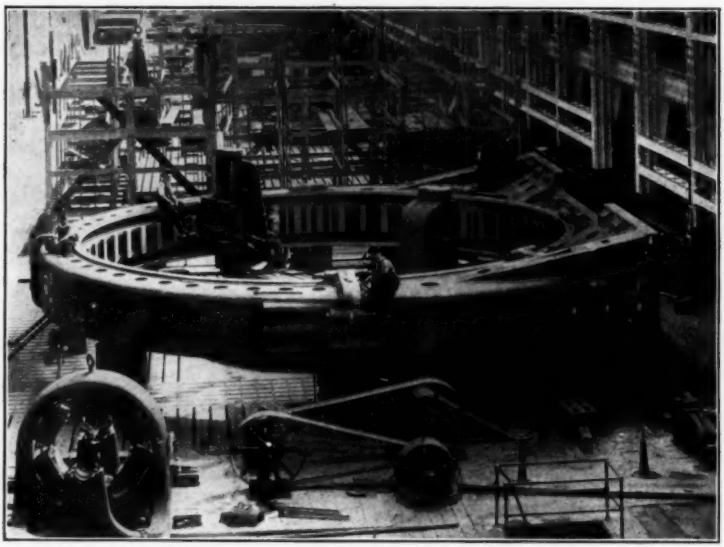


FIG. 11. BED-PLATE FLOOR FOR PORTABLE TOOLS ON HEAVY WORK; NEW MACHINE SHOP OF THE WESTINGHOUSE ELECTRIG & MFG. CO., PITTSBURG, PA.

The tools thus far considered have not been of the automatic type, although designed for special duty. There is the ordinary engine lathe designed for a general line of work; the engine lathe of special design, adapted for doing just one class of work; and, again, the full automatic lathe. Automatic machinery is not of recent origin, but the perfection recently arrived at is, indeed, astonishing. The lathe illustrated by Figure 13 is one of the latest types built by Pratt and Whitney, having a disc magazine, and is capable of handling a very miscellaneous line of work. The air-closing mechanism on the chuck allows considerable variation in size of work, doing away with sorting, which was heretofore necessary. I recently saw one of these machines fitted with a gravity magazine machining sewing-machine hand wheels. They were turned all over, bored, finished, and finally

dropped into a suitable box in 4½ minutes. One man and a helper attended twelve of these machines. I would not venture to say how long it would take to complete this job if machined on an engine lathe of the ordinary type.

As Mr. Norton deals specifically with the subject of grinding elsewhere in this number I need make but passing reference to the subject here. Much has been accomplishd toward more accurate and cheaper product. The grinding machine in its various forms is adapted to the roughest or finest work, and as a result of the makers' investigations machines have been developed that have entirely superseded the lathe for finishing certain kinds of work. The lathe of the future will be used largely for roughing.

FIG. 12. INTERIOR OF THE NEW SHOPS OF THE JEANESVILLE IRON WORKS CO., HAZLETON, PA.

An example of modern practice in arrangement and equipment.

Figure 15 shows one of the largest machines made by the Norton Grinding Machine Co. It grinds shafts over 22 feet long from end to end to an accuracy of a 0.00025 inch in but a small fraction of the time originally required. Seven thousand pounds can be carried on the centers, while the moving work table, together with its head and foot stocks, weighs 6,000 pounds. The machine is equipped with an emery wheel 24 inches in diameter with 2-inch to 4-inch face, and

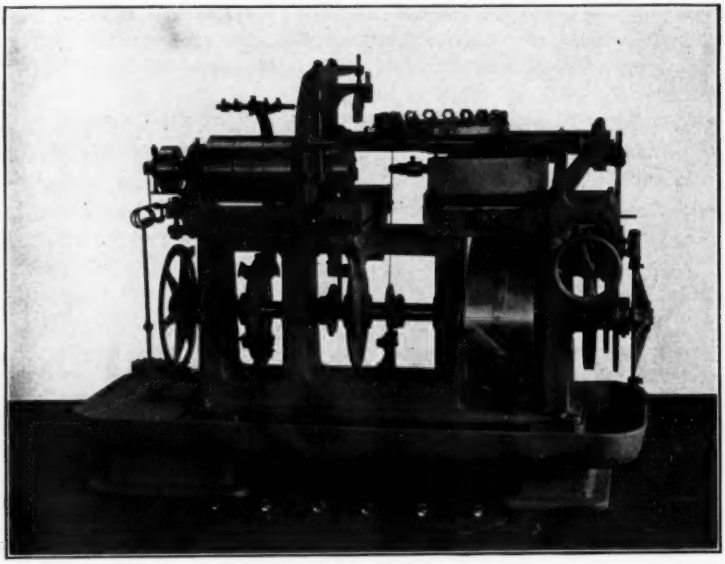


FIG. 13. AUTOMATIC LATHE MANUFACTURED BY THE PRATT & WHITNEY CO., HARTFORD, CONN.

is capable of utilizing 20 horse-power when necessary. On this machine steel work 10 inches in diameter and 10 feet long, rough-turned on the lathe to within 1/32 inch of the finished diameter, was ground and

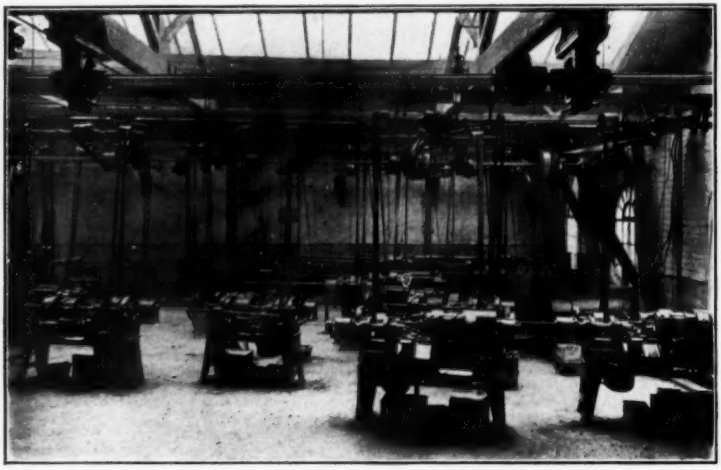


FIG. 14. AUTOMATIC MACHINE-TOOL DEPARTMENT IN THE SHOPS OF MARSHALL, SONS & CO., GAINSBOROUGH, ENGLAND.

finished to the required accuracy in 1 1/2 hours. It would probably require 12 hours to have completed this work in an engine lathe with a file and finishing tool.

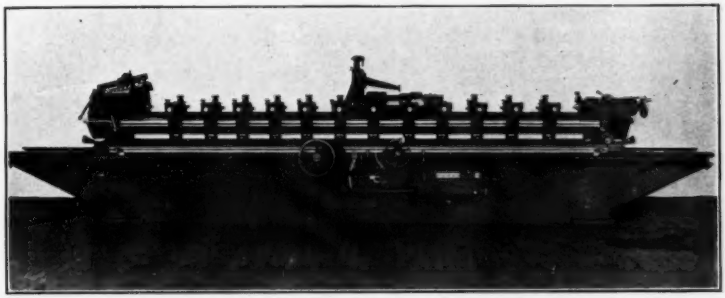


FIG. 15. VERY HEAVY GRINDING MACHINE, BY THE NORTON GRINDING CO., WORCESTER, MASS.

It is now well understood that accuracy and low labor cost may go hand in hand—in other words, interchangeability (one of the most important ends to attain when manufacturing a given line of product in large quantities) should be accompanied with a minimum expenditure of time. The reason for this is clear enough, as accuracy can be attained only by machine work, and machine work is invariably cheaper than hand labor. Think of the cost and the skilled labor that would be required to manufacture a single Colt revolver, and yet, by machinery, these beautiful weapons are made in enormous quantities and assembled without the touch of a file.

We need just as skilled mechanics today as it is possible to obtain, and can afford to pay them high wages, for upon their work largely depends the degree of accuracy attainable. After they have designed and made the necessary dies, jigs, templates, etc., the actual work of manufacture can be carried on by low-priced men. This is the fundamental principle of the modern manufacturing plant. But to keep in the foremost rank it is necessary to use only the most efficient types of apparatus. Competition has become so keen that an improvement in but a detail of a machine may make it impossible for the manufacturer possessing the older type to successfully compete.

There are two articles that will always stand out clearly in my memory: one by Horace Lucian Arnold—"Production to the Power Limit,"* and the other by H. F. J. Porter—"The Radical Policy of Scrapping Costly Machinery."† In Mr. Arnold's paper exception is taken to the old policy of nursing machine tools for fear that they

* THE ENGINEERING MAGAZINE, August, 1895.
† THE ENGINEERING MAGAZINE, January, 1901.

FIG. 16. NEW SHOP OF THE C. R. I. & P. R. R., MOLINE, ILL., SHOWING DRIVING-WHEEL AND CAR-WHEEL LATHES BY THE NILES-BEMENT-POND CO.

may be strained or overworked in any way. He clearly shows its fallacy. The principal item in the cost of production is labor. The time required to do a job is the gauge as to its cost, so that we can well afford to drive every tool to its full capacity, even though such a policy results in a larger repair account. But in the past few years, through investigation and research made possible by our better understanding of such matters, much better results can be obtained through the intelligent direction of machine work rather than merely the driving of a tool by one who wishes to attain its full output but has no knowledge as to what this may be. *The intelligent direction of work characterizes the modern and progressive shop.* Just as the drafting room sprang into existence but a few years ago, so we now find in the most progressive plants a planning department to lay out and direct the shop work in all its details.

While I do not mean to enter into the details of management, I feel that we can never dwell too forcibly upon the importance of such knowledge to those in any way connected with machine-shop work. The tool steel and the machine equipment are of value only in so far as they lend themselves to the accomplishment of economical results in the hands of our workmen, foremen, and superintendents.

The machine-shop problem is an involved one, and to grasp it so fully as to direct all its details with equal intelligence requires the undivided attention of able men in charge of such work.

THE GRINDING MACHINE AS A METAL-CUTTING TOOL.

By C. H. Norton.

Mr. Norton has made cylindrical grinding his study for some eighteen years. His article will do much to dispel the mistaken conception of grinding which has been widely prevalent, and to put the grinding machine in its proper place as a commercial tool in the mechanical world, destined to play an important part in the world's progress in labor saving and labor elevation.—THE EDITORS.

CYLINDRICAL grinding has come to us in the mechanical world by gradual steps, the first step of it, no doubt, being that of a polishing operation; in fact, there are people today whose idea of cylindrical grinding is simply that of producing a polished surface upon the work. There are others who have a little different idea, and yet who still suppose that cylindrical grinding means simply the producing of a perfectly round and straight cylinder with a finished surface to exact diameters, and that because of the possibility of removing *infinitely small amounts of steel* with a grinding wheel, grinding excels only in producing *exact* work. Another thought in regard to grinding is that it is useful only where surfaces are hardened. Still another idea is that grinding may be used only where very delicate work is to be produced.

Within the last six years, developments in grinding have been so great along new lines and methods that today mechanics understand that cylindrical grinding means not only the production of accurate work, but the production also of all cylindrical work in a shorter time than is possible when finishing it to size by the lathe method. Within the last four years machines have been regularly manufactured and sold that remove commercially, when working to their maximum, one cubic inch of steel per minute from cylindrical work. It is easy to understand by the aid of pencil and paper that with this capacity for removing stock, the grinding machine can size cylindrical work to exact diameters much more cheaply than the lathe, when comparatively small amounts of material are to be removed, as represented by cylindrical work that has been roughed in the lathe leaving from 1/64 to 1/32 of an inch diameter. As nearly all cylindrical work can be turned very cheaply to this limit, it is clear that with grinding machines of such capacity, the sizing or finishing cut can be produced

much more quickly than by turning in the lathe, provided the finishing cut of the lathe is of a nature that will allow of filing and finishing.

Some idea of the reason for these possibilities with grinding cylindrical work may be understood when we learn that with many modern grinding machines there are from fifteen to twenty millions of cutting points per minute on the work. This becomes still clearer when we learn, as we have within the last two or three years, that the cutting points of a modern grinding wheel are of such shape and quality that the chips removed by them are curly chips, and while they are irregular in form, they show a cutting action similar to that of a steel pointed tool when turning or milling work.

The difference in capacity between the old-line grinding machine and the modern grinding machine, for removing stock, is shown by reference to the cuts made from micro-photographs; these photographs magnify a little more than twenty diameters.

Number 1 shows a photograph of chips from soft steel, ground from ordinary machinery steel about 4 inches in diameter, ground wet, or better, with a cooling lubricant. This lubricant was made of water, soda, and oil. The grinding wheel was 2 inches wide and 24 inches in diameter. It is known by the makers as No. 24, grade "L," "Alundum" wheel. The wheel was running at a surface speed of 6,000 feet per minute.

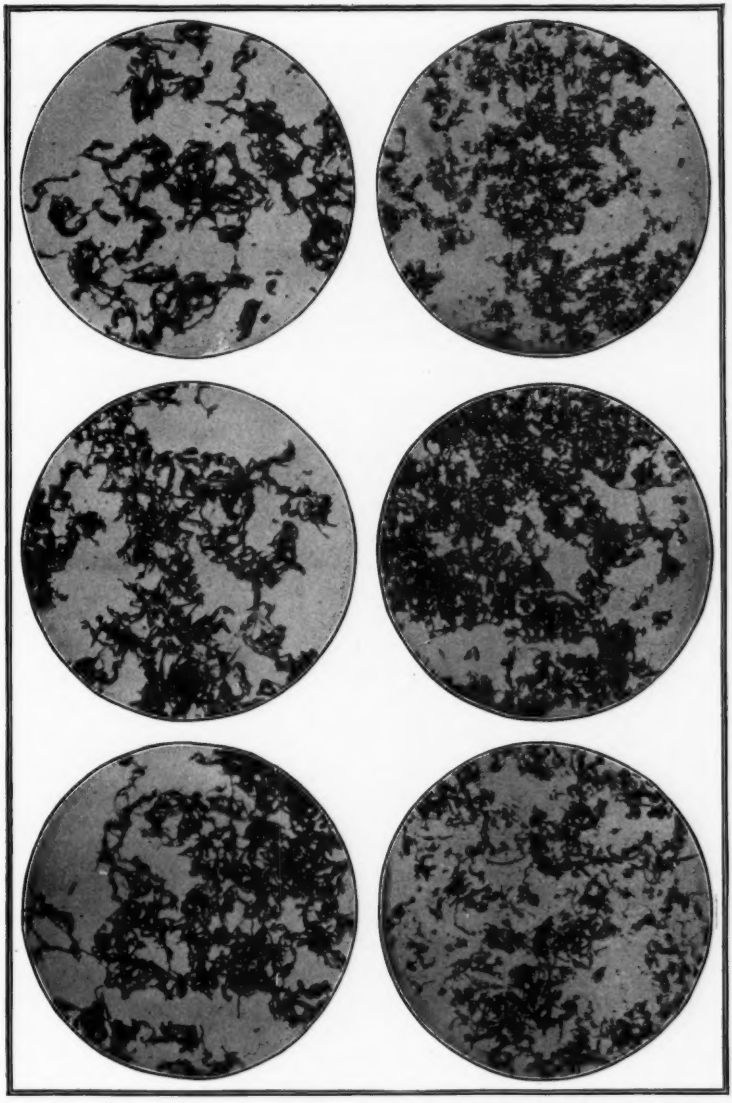
Number 2 shows a photograph of chips ground from the same piece of steel, but by an old-line grinding machine, by the old method. The relative power consumed between the two pieces was approximately about 8 horse power for removing the chips shown in Number 1 photograph and 4 horse power for those shown in Number 2.

In the case of Number 1, there were about nine million cutting points in contact with the work per minute—in the case of Number 2, about seven hundred and twenty thousand.

No. 3 shows a photograph of chips also from soft steel of a little more carbon than the Number 1. Other conditions were the same. It would seem that the greater amount of carbon caused a little difference in the form of the chips with the same treatment.

Number 4 shows a photograph of chips from cast iron. It will be seen that a little more heat develops in grinding cast iron, as there are a very few globules present. These globules are apparently formed by melted particles of iron. There are, however, very few in this specimen, showing excellently clean cutting of the wheel. The wheel used in this case was 2-inch face, with speed of about 6,000 feet per minute cutting surface, and nine million cutting points per minute.

Number 5 is a photograph of chips from hardened tool steel. It is



MICRO-PHOTOGRAPHS OF CHIPS REMOVED BY A MODERN CYLINDRICAL GRINDING MACHINE.

1. Soft steel; modern machine.
2. Soft steel; old time machine.
3. Slightly harder steel.
4. Cast iron.
5. Hardened tool steel.
6. Manganese steel casting.

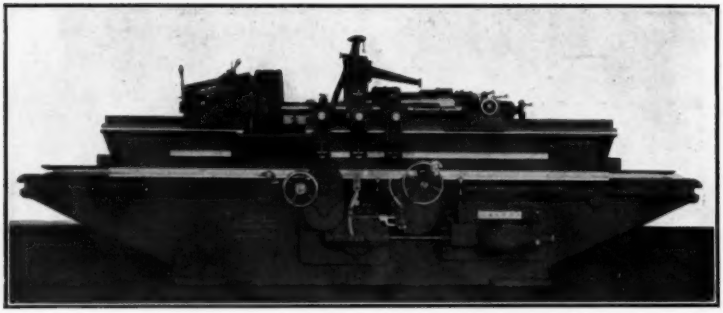


FIG. 7. NORTON GRINDING MACHINE FOR USE IN RAILROAD SHOPS.
Grinding wheel 24 by 4 inches; grinds work 8 ft. long; swings 18 in. diameter.

interesting to note that the chips from hardened steel are also of a curly form. They are, however, finer, because the cutting points of the wheel cannot enter so deeply into the steel. Grinding of hardened steel is consequently somewhat slower than that of soft steel. A No. 24, grade "K" wheel, with 2-inch face and 24-inch diameter, was used for this, with nine mililon cutting points per minute on the work.

Number 6 is a photograph of chips from manganese-steel casting, ground with No. 16 Alundum wheel, grade "N." Manganese casting is, of course, very hard, and the wheel was also relatively hard, an effort being made to use a durable wheel on such rough work. An examination of this picture with a magnifying glass reveals a large number of globules. It is remarkable, however, that there can be any curly chips in this specimen, when we consider the extremely hard substance and the great amount of heat generated by rapid grinding, with a very hard, durable wheel. The globules are, undoubtedly,

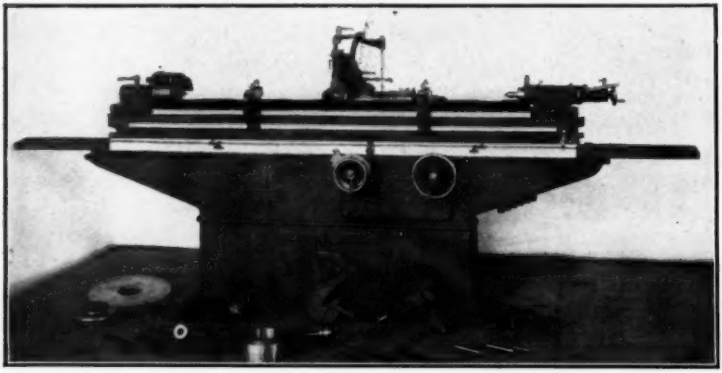


FIG. 8. BROWN & SHARPE 10 BY 72-INCH PLAIN GRINDING MACHINE.

formed from melted particles of the steel overtaken by the flow of water. An interesting feature of these micro-photographs to the grinding expert is this; they show distinctly that the millions of cutting points of the modern grinding wheel act in practically the same way when removing stock as do the familiar steel-cutting tools when turning, milling, or drilling; that is, they really *cut* the steel. Thus, the old conception of grinding, viz., that it is a melting, rubbing, or tearing away of the surface by the grinding wheel, is changed by this revelation of the microscope. Even the worse specimen in this particular—that of the manganese steel, No. 6, shows more than half of the particles to have been cut away, while the remainder may have been cut, but were heated to such an extent as to become melted.

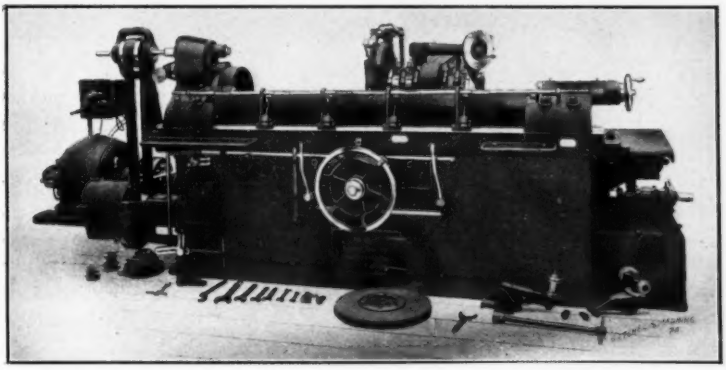


FIG. 9. CYLINDRICAL GRINDING MACHINE, LANDIS TOOL CO., WAYNESBORO, PA.

Figure 10 shows a specimen of work done by a modern grinding machine, and represents a couple of exhaust valves for a Corliss engine. One of them is turned the opposite side towards the observer, and shows the surface left by turning; the other shows the surface left after grinding.

It may be interesting for the reader to know that this particular valve was 26 inches long, 5 1/2 inches diameter; and that it was turned so cheaply in the lathe that the entire time of reducing the diameter 1/4 inch from the casting was only 10 1/2 minutes. It was then ground, reducing the diameter still further, 1/32 inch, in 30 minutes, making the entire time of the cutting tool in the lathe and the cutting wheel in the grinding machine of 40 1/2 minutes, for the production of this ground valve from the rough casting.

Figure 11 shows a lot of plungers for hydraulic cotton presses. They were about 10 inches diameter and 6 feet long. They were ground, complete, removing about 1/32 from the diameter to a thou-

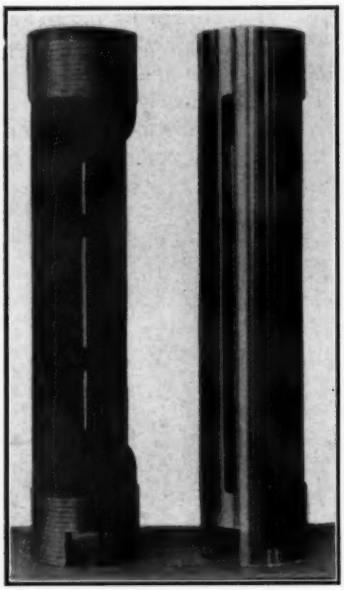


FIG. 10. CORLISS ENGINE VALVES—AN EXAMPLE OF GRINDING.

sandth inch limit for variation of diameter between different ones, and straight, to one-quarter of a thousandth limit of diameter between the two ends. The time consumed in doing this was one hour and a half each. It is quite easy to understand that a lathe operation would require several hours for producing this accurate diameter and finish, after the rough turning was done.

Some idea of the ease with which difficult cylindrical work can be produced may be had by a study of Figure 12 which shows crucible-steel bars 7 feet long, the largest of which is 3 inches diameter, the smallest in the picture being 3/4-inch diameter. and the middle one 7/8-inch diameter. These smaller bars were ground upon centers without turning in the lathe, from the rough black bar, removing 1/16-inch from the diameter. The limit for accuracy was 0.001 an inch in the entire length, and round within a very small fraction. The time consumed in grinding the small bars was three hours each. The large bar was first turned, leaving 1/32-inch to be removed; that also was ground in three hours. An attempt to finish to this degree of accuracy such small pieces in the lathe would either result in failure, or require many times three hours.

The writer witnessed the grinding of some shafts that were 8 inches in diameter and 8 feet long, made of machine steel about 40 points carbon. They were ground, removing 1/32 of an inch from the diameter, complete in two hours each, accurate to gauge, and perfectly round, with a nice finish.

Numerous instances could be cited to show that the modern cylindrical grinding machine is really a metal-cutting tool. As at present designed, it is capable of removing a sufficient amount of metal per minute to enable it to compete successfully with the engine lathe for producing diameters, as well as finish, after roughing cuts in the lathe have been made. There are also instances like the long, slim bars

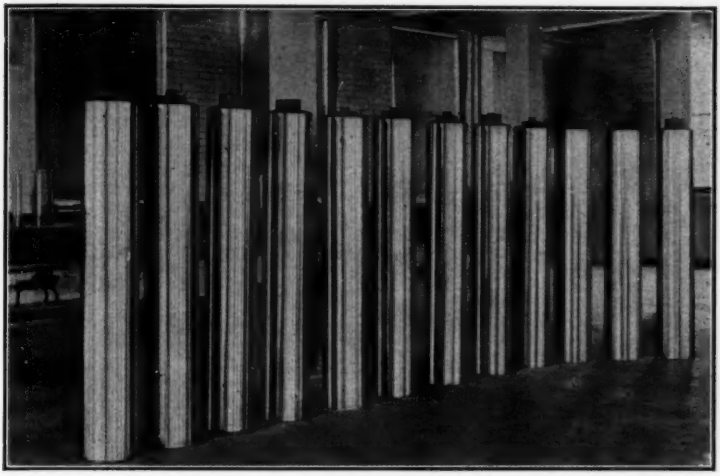


FIG. 11. PLUNGERS FOR HYDRAULIC COTTON PRESSES, FINISHED ON THE GRINDING MACHINE.

shown, where a grinding machine does away with the lathe entirely with a great saving of time, the work being very slim and difficult to turn. In the case of locomotive work, piston rods that have been in long service are removed from the engine with the heads intact and are reduced in diameter sufficient for the next size packing rings, ground and finished directly in the grinding machine, without returning, at a great saving of time over the lathe method. In some cases, the rods being bent and badly worn, as much as 1/32-inch radius is removed by this grinding. The time consumed for regrinding and repairing a rod by this method varies from 15 to 25 minutes, complete, from the floor, into the machine and out, the time depending very much on the condition of the rod when taken from the engine.

The grinding machine today has taken its place as a practical metal-cutting tool to be used by progressive manufacturers as a labor saver, and manufacturers to whose attention its possibilities have been

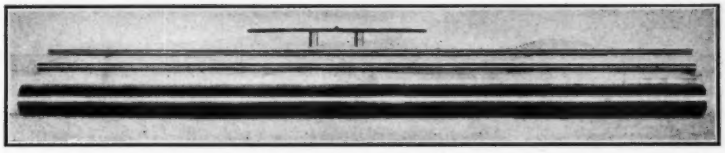


FIG. 12. DIFFICULT CYLINDRICAL WORK PRODUCED IN THE GRINDING MACHINE. CRUCIBLE STEEL BARS, 3 INCHES, 7/8-INCH, AND 3/4-INCH IN DIAMETER.

brought, by practical demonstrations, have accepted it as a settled method of sizing cylindrical work, as well as finishing.

As a labor-saving tool, it has been, and to a large extent, it is yet unpopular with labor organizations. This feeling, however, will soon be reversed, in my opinion, for the reason that workmen are learning that by the use of the grinding machine they can make themselves very much more valuable, and thereby gain a larger income.

It is very gratifying to the thinking workman to know that he can so easily, by little experience with the grinding machine, produce such beautiful work in so short a time, and where operators have passed the first stage of their experience with the machines they become intensely interested in them and their work, so that it is probable that ere long the cylindrical grinding machine will be a fixed factor in the production of all round work in the mechanical arts, and that pride in its operation by workmen will be greater than is now shown by operators of the lathe and the planer.

The grinding machine, requiring as it does more thought, greater caution and intelligence in its operation than the lathe or planer, I believe tends to elevate the position of the workmen rather than to degrade it. This view is being taken by many workmen today, who a few years ago were opposed to it.

There is great need of thinking young men who may not have the knowledge of a machine trade, but who have natural tact, care, and refinement in their methods, to become experts in the manipulation of modern cylindrical grinding machines. The field is wide and the demand for such men is, at this time, increasing. When young men shall take the grinding machine seriously and treat it as a friend, with the respect which is due it, and employers shall find they are in earnest and skilled in their manipulation of it, its possibilities for labor saving are so great that the earning power of young men, in connection with the grinding machine, will be larger (in my opinion) than is possible with any other machine tool now known.

The thinking mechanic has a feeling of great satisfaction when he produces commercially what is known as really fine work. As the grinding machine becomes known and used by such men, there must be an enlarged feeling of satisfaction that they can contribute to the world's progress such quality of work at such a minimum cost, and as our workmen become better acquainted with the real laws of progress and of growth in the mechanical world, and as our difficulties between labor and capital become better adjusted, the grinding machine will take a more important place than have any of the machine tools which have preceded it.

DIMENSION LIMITS AND LIMIT GAUGES; THEIR PRACTICAL USES AND RESULTS.

By Arthur A. Fuller.

The phase of practice reviewed by Mr. Fuller lies at the very foundation of the system of standardization and interchangeability, which is in its turn the basis of modern cheap production. It is one of the central principles of up-to-date manufacturing.—THE EDITORS.

THE use of limit gauges for standardizing the products of the machine shop is particularly advantageous for shops manufacturing a standard line of machines, but is also clearly applicable to certain parts of machine work in smaller shops making a wide range of product in small quantities; for in all machine construction there are certain operations performed by standard machine tools, which produce parts having similar geometrical shapes, such as cylindrical or plane surfaces, and these surfaces must be made with an accuracy suitable to the purpose of the mechanism under construction.

There are two methods in vogue for the attainment of this necessary accuracy. The first, still employed in some very large establishments, consist of placing a certain dimension on the drawing, and of having in the shop a single gauge to represent this dimension. This gauge sometimes corresponds exactly to the figure on the drawing, but often is a modification of this figure to allow the piece to properly fit its neighbor. In this latter case, the gauge is usually stamped first with its size in inches and decimals thereof, and second with the special use for which it is intended. The workman attempts to work to this gauge, and an inspector decides whether or not he has successfully accomplished his task. Many factories use this method only for parts or places requiring accurate fitting, leaving the balance of the dimensions called for by the drawing to be produced by the use of boxwood rules or steel scales. We may call this the "single-dimension method." The second method consists of placing on the shop drawings for a required size, two distinct dimensions, one maximum and one minimum, and of having in the shop either two positive gauges, called limit gauges, representing the two given dimensions, or an adjustable measuring instrument capable of being quickly adjusted to the two required sizes. When the workman has brought his work to a size between the two sizes called for, his task is accomplished. This

method, if carried to an extreme, would require two dimensions for every size specified on the drawings; few shops, however, do this, but many use the method for certain parts of their work, where experience or past troubles have driven them to it. Other shops do not specify these dimension limits on their drawings, but have standard shop limit gauges which are to be used for all shop work of a given kind. The use of two dimensions, or maximum and minimum gauges, we may call the "dimension-limit method."

Much excellent work is produced by the single-dimension method, and if you ask the shop management how closely the work has to conform to the gauge, you will, almost without exception, receive the reply that it has to be "exactly" the size of the gauge; but upon closer questioning, a most alarming variation in the definition of this word "exact" will be divulged. For some cases, the piece might vary 0.01 inch from the gauge, and still answer every purpose of construction, and satisfy the inspector; in other cases, 0.001 inch variation might not answer for constructive purpose, nor satisfy the inspector, and even if the workman has been given verbal instructions as to the degree of accuracy required, he is never quite sure whether or not he has reached the requirement. It has been said by one of the most expert shop managers of the United States that "it is not work, but worry which wears most on the workman." Is it fair, then, to place upon the workman so uncertain a task? Is it fair to leave the acceptance, or rejection, of his work to another man's touch, which may be more or less delicate than his own? Is it good shop management to allow a man to spend time in attempting to fit a piece accurately to a single gauge, when anywhere within a half a thousandth, or even two thousandths of an inch, will answer every purpose?

But perhaps, you say, even plus or minus half a thousandth cannot be allowed; granted; but some limit must be allowable, for neither tools nor workman can produce absolute perfection. Whatever then is allowable can be specified, either by dimension limits or limit gauges. The best draughting rooms show the most attention to detail, and specify most explicitly the requirements for the finished product. It is simply impossible to modify a dimension by an adjective expression which will mean the same to every engineer, foreman, workman, or inspector connected with the work. It is, therefore, evident that if definiteness of instruction, uniformity of product, and contentment of the workman are desired, something different from the single-dimension method is required. Experience is proving that the dimension-limit method removes, in a simple and direct way, the disadvantages of the old system. Its most satisfactory application consists of

placing dimension limits on the drawings for some classes of work, and of having shop limit gauges for other classes of work.

Under the latter class, the cylindrical hole falls most naturally, as the expression "standard hole" is perhaps more frequently heard than any other in the machine shop. Nevertheless, only a small portion of the holes made in a shop are ever gauged in any way to determine their size. Rough-drilled holes often answer every purpose; reamed holes varying from plus or minus 0.002 inch will answer many purposes; while for other good commercial work, only plus or minus 0.00025 inch can be allowed. For a drilled hole, the word "drill" is usually thought to be sufficiently definite to specify on the drawing, and for finer work the word "ream" is commonly employed. Such specification will answer for a large class of cases, as drills sharpened on a drill grinder, and used with ordinary care, will produce a hole within 0.01 inch or 0.02 inch of its own size; but even so, a shop inspecting its own work could use, to advantage, a set of rough-limit plug gauges in insure, first, that the correct size of drill has been used, and second, that the drill used is producing holes within say 0.02 inch of its intended size.

For reamed holes, the necessity for limit gauges is absolute. Where the work is uniform, one set of gauges may answer for a shop standard, the limit allowed conforming to the character of the work. If only one set of limits is used, the word "ream" on the drawing is sufficient, but if different degrees of accuracy are desired, some sign will be nesessary to designate which set of gauges is to be used, say set A or B. One noted New England shop uses a limit from standard to minus 0.001 inch for all ordinary holes, and a single-standard plug gauge for finer work. Another shop uses, for holes below 1¼ inch, a limit of plus or minus 0.00025 inch; for holes between 1¼ inch and 2½ inches, plus 0.00075 inch and minus 0.00025 inch; for holes over 2½ inches, plus or minus 0.001 inch. Perhaps these various hole limits illustrate better than anything else how well the dimension-limit system adapts itself to any degree of accuracy required. With the modern methods of grinding and lapping, several of the best tool shops of the United States could furnish limit plug gauges varying plus 0.0001 inch, and minus 0.0001 inch from standard, which, of course, would mean a very high grade of commercial work for reamed holes; but even such a set of gauges would be more satisfactory to work with, than one gauge with the requirement that the hole must be "exact" size of the gauge.

Having established limits suitable for holes, the next problem is to establish limits for cylinders designed to be some special fit, such as

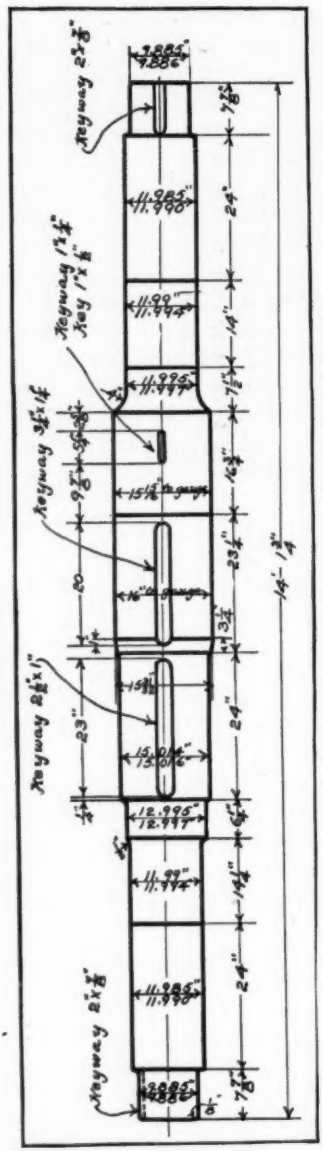


FIG. 1. LIMITS FOR THE VARIOUS FITS ON AN ENGINE SHAFT.

a force, drive, or running fit, in these holes. I was formerly of the opinion that limit wires, or rods, for each of these fits, and for all diameters in common use, should be made and handed out to the workman with his drawing or other instructions for the work; but the development of the micrometer caliper into larger sizes at a moderate cost has altered the conditions, so that today a more flexible and less expensive system is obtained by the purchase of these instruments in sufficient quantity to satisfy the requirements of the shop. These allow a wider range of fits for any given size of hole, for it is found, in some cases, that fits depend on the kind and form of material being used. Figure 1 shows an engine shaft with the limits allowed for the various fits specified thereon. The portions marked 15-15/16 inches and 16 inches "to gauge" are so designated to accommodate the single-gauge system of the armature builder who, in this case, furnishes the engine builder with a single gauge for this portion of the shaft. As a matter of fact, if this portion is turned to within plus or minus 0.001 inch of this gauge, the armature builder would probably not hesitate to force on his armature. This degree of accuracy is readily obtainable on such work, and if a limit of only plus or minus 0.0005 inch were allowed, it would be more satisfactory to work to than the single dimension, although it would require great care.

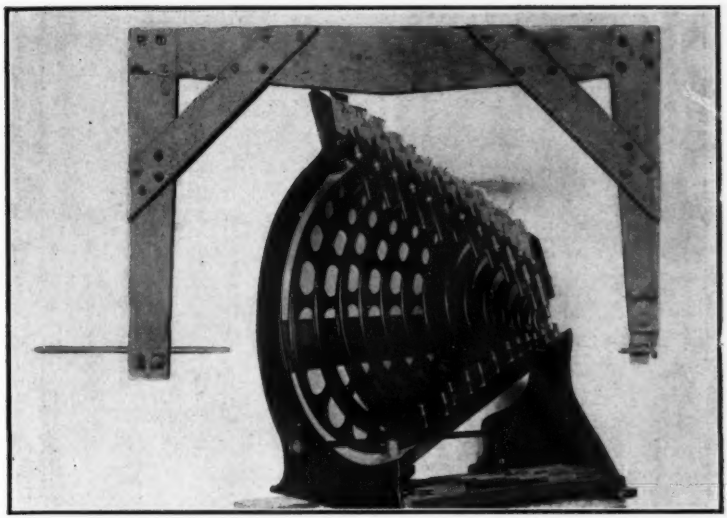


FIG. 2. SET OF SLOCOMB STEEL FRAME MICROMETERS, 0 TO 12 INCHES. ALSO HOME-MADE PINE-FRAME CALIPER WITH MICROMETER POINTS, USED WITH STANDARD RODS TO MEASURE FROM 18 TO 22 INCHES.

Dimension limits are particularly adapted to producing interchangeable work, but may also be employed to produce a desired closeness of fit, independent of the actual size. Thus, Figure 3 shows an assembled vacuum pot for a steam engine. In this case, it is not necessary, or even desirable, for the different parts of these pots to be interchangeable. But it is absolutely necessary for the successful working of the pot that the clearances for the running fits be uniform within very narrow limits. In this case, the exact sizes are not expressed on the detailed drawings, but simply the nominal dimensions, but the table of allowed variations, shown in Figure 4, is given to the workman with the drawing. By a careful study of the table it will be observed that not only is the allowed difference in diameter between the two pieces specified, but also the allowed ellipticity or variation in diameter for each piece, and the sum of the ellipticity for the two pieces. In order to obtain such accuracy, it is necessary to grind the plunger and bottom together by means of ground glass and oil.

Before the application of the dimension-limit system to this work, a very peculiar experience was met with. The pots were made in identically the same manner as at present. The plungers were first bored to diameter, and the bottoms then turned to match, leaving a

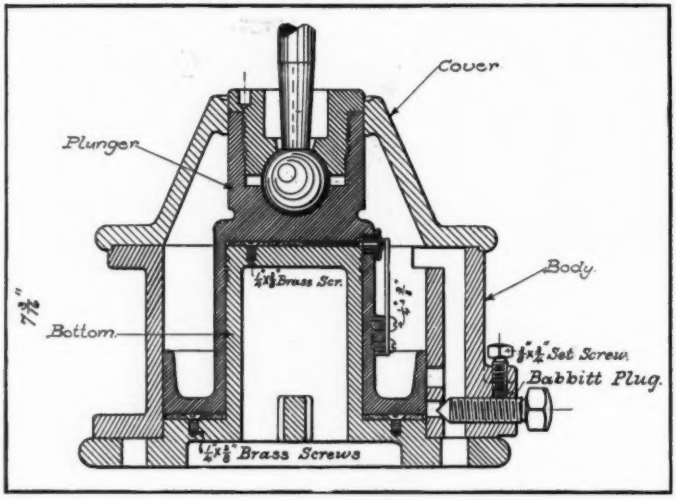


FIG. 3. SECTION OF ASSEMBLED DASH POT FOR A STEAM ENGINE.

few thousandths for grinding. After grinding, the pots were placed in a testing machine, arranged to give them a variable lift, and any desired number of strokes per minute, were run for several hours, and finally landed in the stock room. Erecting men soon began to report the most erratic actions of some of these pots, the most common difficulty being that of sticking or seizing. Upon measuring the diameters of these pieces, it was found that the diameter of the hole in the plunger was smaller than the cylindrical portion of the bottom, by 0.001 inch to 0.0015 inch, for its entire length with the exception of an enlargement, or taper, at the mouth of the hole, extending in about ½ inch. This allowed the bottom to enter the plunger, and, as long as the two pieces were in motion, either when revolving in the lathe during the grinding process, or while stroking up and down under the testing machine, the two pieces would move freely one upon the other—so freely, in fact, that either of these motions could be easily duplicated by hand. If, however, the two pieces were left together for a few minutes, they would seize so tightly, even if thoroughly oiled, that it required several severe blows from a lead hammer to free the parts. Proper precautions were taken to obviate the influence of expansion due to heat, and, of course, when running together the plunger was larger than the bottom, but the small amount of work required to cause the expansion of the plunger and the compression of the bottom sufficient to allow them to run, was simply paradoxical. However, the

seizing was a decided defect that entirely disappeared under the dimension-limit method.

A more difficult field for dimension limits is found in the fit between a thread and its nut when both are made several diameters long. Here the pitch is essential as well as the diameter. Threaded holes are made standard by using expansible taps, or by threading with a tool in the lathe until a minimum threaded sizer will enter. For the exterior thread the pitch is easily determined by testing the travel of the carriage of the lathe, by means of a vernier allowing only a specified variation, and the diameter by means of a "V" thread micrometer. As the latter are regularly manufactured only in small sizes, a "V" thread comparator in connection with any threaded sizer representing the shop standard is a practical and inexpensive instrument for gauging threads. This instrument is "C" shaped similar to the "V" micrometer point at the other, but does not give any absolute readings in inches. It is given to the workman with the threaded sizer from the tool room. The workman first calipers this sizer, with the comparator, obtaining an arbitrary reading; he then threads his pieces within specified limits of this reading, say 0.003 inch to 0.005 inch under, for a given diameter, to allow his work to screw with the proper looseness into the threaded hole.

Although diameter limits are important, simple length limits are often time-savers. It is also true that dimension limits applied to the

Working Limits for Running Fits for R. & S. Dash Pots.

D: differences in diameter between the two pieces. Must not be greater than maximum or less than minimum.

V: variation in diameter on either piece. Must not exceed.

S: sum of variations in diameters on the two pieces. Must not exceed.

L difference in length. Must not exceed.

Nominal Size of Dash Pot	Turning Bottom & Boring Plunger				Boring Body & Turning Plunger			Turning Plunger & Boring Cover		
	D	V	S	L	D	V	S	D	V	S
3″	.00000 .00025	.00025	.00025	.005	.002 .004	.0015	.002	.003 .006	.002	.003
4½″	.00025 .00050	.00025	.00050	.005	.003 .005	.0015	.002	.004 .007	.002	.003
5″	.00025 .00050	.00025	.00050	.010	.004 .006	.0015	.002	.005 .008	.002	.003
6⅞″	.00050 .00100	.00050	.00100	.010	.005 .008	.0020	.003	.006 .010	.003	.004
9⅞ 12″	.00050 .00100	.00050	.00100	.015	.006 .009	.0020	.003	.008 .012	.003	.004

Holes should be standard as near as possible

Exterior diameters left undersize to obtain specified running fits.

Providence Engineering Works.

FIG. 4. TABLE OF ALLOWED VARIATIONS IN THE DASH POT SHOWN OPPOSITE.

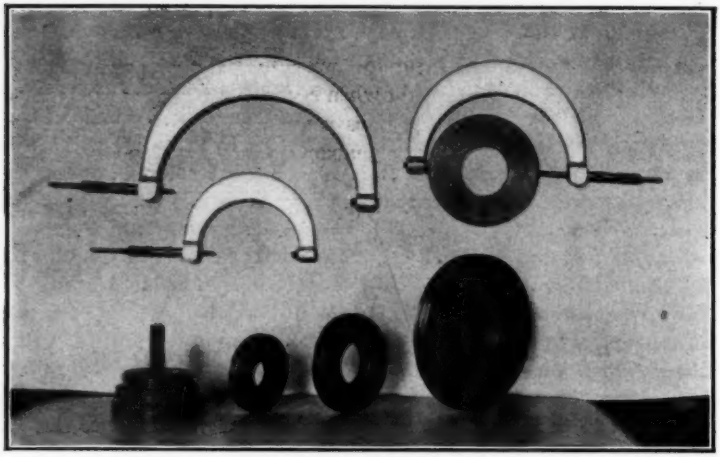


FIG. 5. THREADED DISC SIZERS AND ALUMINIUM-FRAME THREAD COMPARATORS WITH MICROMETER POINTS.

coarser or less particular work of the shop may save a large amount of time and needless expense. For a length, plus or minus 1/4 inch variation is worth specifying, and enables a man to use a tape line or a pole; or a limit of from standard to plus 1/16 inch will enable a man to use his measuring rule with impunity and feel sure of the result; while plus or minus 0.01 inch would lead him to use a steel scale with great care, and plus or minus 0.001 inch would show him that special length gauges or vernier measurements were necessary.

For compound lengths and for pieces of complicated shapes, it is often an interesting problem and one calling for the best of mechanical judgment to prescribe limits which will not add up so rapidly as to be prohibitive as totals, and it is sometimes advisable not to allow the summation of successive maximum and minimum length limits to hold as an overall dimension; a note calling attention to this should be added so that the workman may not be led into difficulties.

In conclusion, the principal labor-saving factor of the dimension-limit system lies in this one fact, that the "good enough" point is defined to the workman in positive measurements or by positive gauges which leave no doubt in his mind as to the degree of accuracy required. The system requires the closest touch between the shop and draughting room, so that only the most practical limits will be specified. For shops employing an uneducated class of labor, or where it is not desirable to send dimensioned drawings into the shop, limit gauges for all dimensions will accomplish the same purpose.

INSPECTION AS A FACTOR IN CHEAP PRODUCTION.

By Charles U. Carpenter.

Inspection is the corollary and complement of standardized manufacturing. Mr. Carpenter's theme is therefore to the works manager what Mr. Fuller's is to the mechanical superintendent of the factory.—THE EDITORS.

"CHEAPER Production" is today the war cry of superintendents, managers, and manufacturers. Strenuous efforts are constantly being put forth and every device is being adopted to accomplish this. Improved automatics of every description, latest types of extra heavy machinery that can be worked to the limit of speed and feed, new high-speed steel cutting tools and small tools of all kinds, are being introduced constantly; improved methods of factory accounting are being seized upon, in order that the manufacturer may determine with certainty what processes should be first attacked; work is being carefully analyzed and specialized; the individual workman is being stimulated to a high rate of production by new systems of pay. Every nerve is strained to reach "cheaper production."

That the result will be reached cannot be disputed. But is the ordinary factory properly organized to care for work produced under such new conditions? Is there provided any method by which the manufacturer can be guaranteed work of as high quality as formerly produced? Or can he feel sure that the saving made at one point of manufacturing is not consumed at another point, through extra time consumed in fitting and adjusting defective parts? We may be sure that, unless proper precautions are adopted, this "rushing of production" is attended with much danger.

I have in mind the product of two large concerns which have been very active in the introduction of up-to-date methods of production and of lowering costs. But the decline in the quality of their product, and the consequent loss of a prestige gained through long years of endeavor, is a striking demonstration of the folly of such methods when these methods are not coupled with a thorough system of overseeing the work, or "inspection."

In still another case large sums are being lost in the erection of heavy jobs because of inaccurate shop work. Such losses are by no means uncommon. The executive officers are usually unaware of the

conditions, as every effort is made to conceal errors. As a consequence, loss of prestige or cash comes upon them as a total surprise.

In the midst of this rush one must conclude that the need of inspection, great as it was under old conditions, is intensified by the use of these new means of production. The average manufacturer considers it well-nigh a useless expense to employ men to look over work done by other employees. He will seldom look upon the inspection as a strong factor in the reduction of his costs and will often refuse to permit of the expenditure of the sum necessary to secure it. This is a great mistake. He may be sure that the tendency toward specialization of work and intensifying of output will render some comprehensive system of inspection absolutely necessary. Workmen will generally do no better work than they are required to do. With foreman and superintendent constantly after them, with records before them notifying them of the time in which a job can and should be done, with the bait of increased pay dangling before their eyes, and the feeling that to hold their job they must make the record, it is but natural that they should slight the quality of the work, when they know there is a good chance that such work will not be detected. Under such circumstances the amount saved will usually be lost many times over in the final assembling of the machine. This is especially true when the work of assembling, as well as machining, is highly specialized. In the case of complicated machines especially it is far more economical to specialize the assembling of parts and complete the machine, job by job, than to have one or more men assemble all the parts into the machine. It is evident that the approved plan of specialization makes close inspection all the more necessary.

Results of Inspection.—First, quality. It needs no argument to demonstrate that a rigid system of inspection will improve a bad article or keep up the quality of one already good. The prompt rejection of imperfect parts (for which the workman must pay) soon convinces even the careless one that it is to his interest to produce work of a satisfactory character. An inspector with a first-class backbone will soon instil this into the minds of the men. It is surprising, too, to note how quickly men can reach a high standard of work, and adhere to it, if it be insisted on, and how small will be the loss.

Among many personal experiences I recall a case that was a typical one. It was necessary to drill and ream holes ½ inch in diameter in three lugs, located 3 inches apart, projecting from a small iron casting. These holes had to be reamed within a limit of 0.0005 inch under ½ inch. On the first lot of 400 parts finished, the inspector promptly rejected 398; on the second lot of 350 he rejected 32; but on all lots

after that the loss did not exceed one-half of one per cent. In this particular factory the total per cent. of loss on a total of 20,000,000 pieces inspected per year did not at any time exceed *one-fourth of one per cent.* All losses caused by carelessness were charged against the workmen. Undoubtedly the cause of this low per cent. of rejection was the concentration of the workman's attention upon his work. This results from his feeling that he will be paid only for good work and will suffer for his bad work. Excellent results can be secured, especially in small shops, by keeping a record of results of different workmen's output, and thus finding out the efficient and inefficient workmen.

The importance of keeping up the quality of work cannot be overestimated. It is often a comparatively easy matter to hide defects by a liberal application of plaster and paint, so that a job upon shipment may be perfect as far as appearances go, only to cause trouble, incur expense, and damage reputation after it has reached the customer.

Quantity.—The fear that careful inspection will seriously affect the quantity of work turned out per man is unfounded. While it is true that in some cases where extreme carelessness has prevailed some diminution in output can be expected, a mechanic working upon ordinarily close work will turn out practically the same amount of work whether inspected or not, under conditions as at present existing in up-to-date shops, where he is provided with proper tools and gauges, instruction cards, etc. The fact that the concentration of his attention upon the work must be increased by reason of this inspection will result in many cases in an increased output. A wide experience in this work leads me to the belief that under usual conditions the manufacturer cannot afford to do without a careful system of inspection, and that the effect on the product both as regards quantity and quality will be surprisingly favorable.

Elimination of Imperfect Parts.—The elimination of imperfections before work goes to the final assemblers is of great importance. In fact, this is absolutely necessary in order to have rapid, accurate, and cheap assembling. As stated before, modern economical methods generally require that the component parts of a machine be assembled job after job, until the machine itself is finally completed. The economy of this method over the old one of having the entire machine assembled by one man cannot be doubted. But, as can readily be seen, these parts must be accurately machined, and unless inspected there is no assurance, and indeed little likelihood, of such being the case. Generally speaking, the specialization of assembling and the elimination of filing and fitting in the assembling departments, through accurate machine work, will result in very satisfactory economies. A walk

through the average assembling department by one who closely observes the assemblers at work, will show the possibilities in the case.

Accurate machining, which can be produced only through careful inspection, will enable the workmen to assemble the parts so much more accurately and quickly that the saving to these departments alone will often pay many times over for the cost of inspection. Again, the product itself will be much more accurately built. The accurate duplications of parts effect not only the ease of assembling, but also the ease of repairs. This in itself is often a very important item. The larger the business, the more important does it become.

Protection.—A proper, even though simple, system will provide needed protection to the company through the fact that the workmen will receive pay only for good work and will be charged with all bad work. This in itself is a valuable economic factor. In many factories the checking up of time tickets is not done systematically or carefully. This leaves a way open for those not honestly disposed to take advantage of the firm. In a well systematized factory the checking up of tickets becomes an important feature of the system. It is also well to arrange wherever possible to have different inspectors examine different operations upon the same lot of stock. In this manner one inspector will check the other.

Authority of the Inspector.—The authority of the inspector and his decisions should be unquestioned. Weakness on his part will be noted immediately by the men and advantage taken of it. If they conclude that by appealing to a higher authority his decisions can be reversed they will soon make his lot a warm one. I have known instances where the men purposely lowered the quality of their work little by little, in order to discover the limit that the inspector would allow. Good men are needed for inspectors, as the qualifications necessary to make a success of such a position are many and peculiar. A well organized inspection force, even though small, often provides a good training ground for bright men. Indeed, the success of a product often depends upon careful inspection. The more complicated the product the greater the need.

In some factories a separate inspection department is provided, and all work is brought to this department to be inspected. This need not be done on every operation but should be done on all those requiring close examination. When this is possible the advantages are numerous. The work will thus always be under the eye of the head inspector, and the inspectors themselves will not be subject to any improper influence on the part of the workmen to slight their work. This factor of "influence" is not to be neglected. In one factory when very

close work was necessary it was found impossible to secure proper results until the inspectors had been taken away from the machine rooms. It was also found that the extra expense of hauling the work to the inspection department was more than made up by the time gained by the inspectors themselves in their own work. Again, the many valuable gauges were thus kept under the control of the head inspector instead of being scattered through the shop. This is often important, not only because of their value, but also because they can thus be examined frequently for accuracy.

In many cases, however, owing to the nature of the work, it is impossible to form such a department. The inspectors must go to the work. In such cases an inspector's report is necessary. Such a report can be so devised as to provide a check upon the inspector both for accuracy of work and time consumed by him in inspecting. Much time can be wasted in this work unless proper checks are kept upon it. Care must be used in such cases to see that the inspector properly accounts for all gauges used by him.

In some factories one workman is used to inspect the work done by the man on the preceding job. On work of a simple character this plan is fairly effective, but it may well be considered crude when applied to complicated or close work. The time lost by the workman will be many times the amount consumed by an expert inspector. Again, in many cases where men are working side-by-side the one will not report his mate, but will either attempt to use work that should be rejected or will turn it back without any report. In this way an error may exist in work and not be discovered until too late. In any event the firm loses this time and also the opportunity of discovering its good and its bad workmen—a most important feature.

It is of course obvious that a thorough final inspection should be given all articles. It is important to note the necessity of giving it one inspection before the final finishing of the work. Plaster and paint skilfully distributed are first-class agents in concealing bad work.

Inspection of Scrap.—It is important that proper attention be given to the question of scrap. In the first place, whenever possible the strict rule should be made that no one but the inspectors can consign any stock to the scrap heap. Stock coming from any department should not be be scrapped without a full explanation from the foreman. In many cases it is advisable to hold the scrap stock for the superintendent's attention. Meetings of the foremen, with the scrap before them, can be held with very good results. The reasons for heavy wastes can thus be determined easily and accurately. The foremen should be continually checked up on this, and held subject to

severe censure for unreasonable losses. When they realize that explanations and reasons must be forthcoming they very soon give this matter their personal attention. Few firms realize the amount of money lost through lack of attention to this detail.

Examination of Gauges.—Most important is it to have some system whereby all gauges and tools, both in inspectors' and machine departments, shall be inspected regularly and compared with the tool models, to ascertain whether or not they have become worn. The neglect of this seemingly small point has worked more than one firm's undoing. Large losses have accrued in many instances through the machining and assembling of parts that are "correct according to incorrect gauges only." Even with the exercise of care and vigilance it is possible for such defective work to get out of the factory, only to cause large losses afterwards. To overcome this it is only necessary for either the tool maker, or the head inspector, (preferably the former) to keep a card index of all tools and gauges used throughout the factory. By the proper arrangement of cards so that each tool or gauge will be called to his attention for examination in its proper turn, what might be a formidable task becomes easy, and accuracy of these important parts is insured.

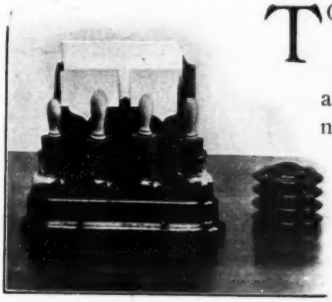
Scope of Inspection.—Inspection in its broadest sense is by no means limited to the work so far discussed. The idea may be profitably extended to more than one branch of business. Among the most important is the inspection of designs and drawings. This is particularly the case in work where standardization is not possible. Many a firm has been driven to the verge of ruin through following blindly the designs of a fanciful theorist, who designs the work without regard to either the economy or the practicability of its production. The closest possible touch between factory and designing department is absolutely necessary. The designing department should not be permitted to send new designs into the shop until these have been inspected by the shop foremen. A meeting between the two divisions should be arranged to provide for a discussion of the most economical methods of designing work and of producing it. In other words, not only should the work of the foremen be inspected, but also the work of the designing room should be most carefully checked up, errors corrected, and means discussed for cheapening the production.

Every manufacturer should pause in the midst of the rush and ask himself if the quality of his product is safeguarded by a proper and efficient inspection system. The need of such work is greatly increased by reason of the greater speed of production which is being attained by reason of new tools and new processes.

THE DRAFTING DEPARTMENT AS A FACTOR IN ECONOMICAL SHOP MANAGEMENT.

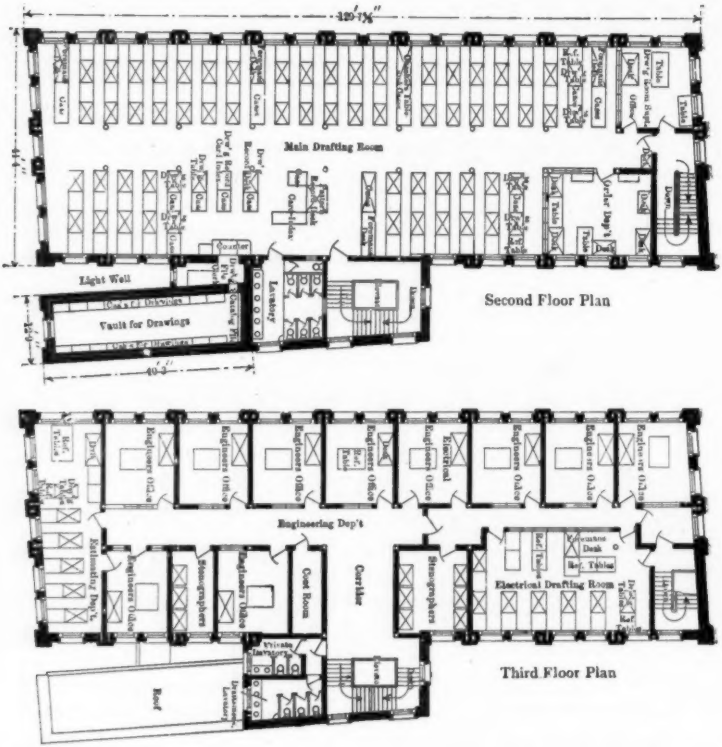
By L. D. Burlingame.

Logically, the drafting department should take its place early in the consideration of a thoroughly efficient system of shop management. Chronologically, however, the policy which Mr. Burlingame advocates belongs quite to the modern era. It is one of the features of practice which strikes Continental engineers, at least, as most distinctively and characteristically American. It is especially interesting to have it discussed by one who has been identified with notable success in its administration.—The Editors.



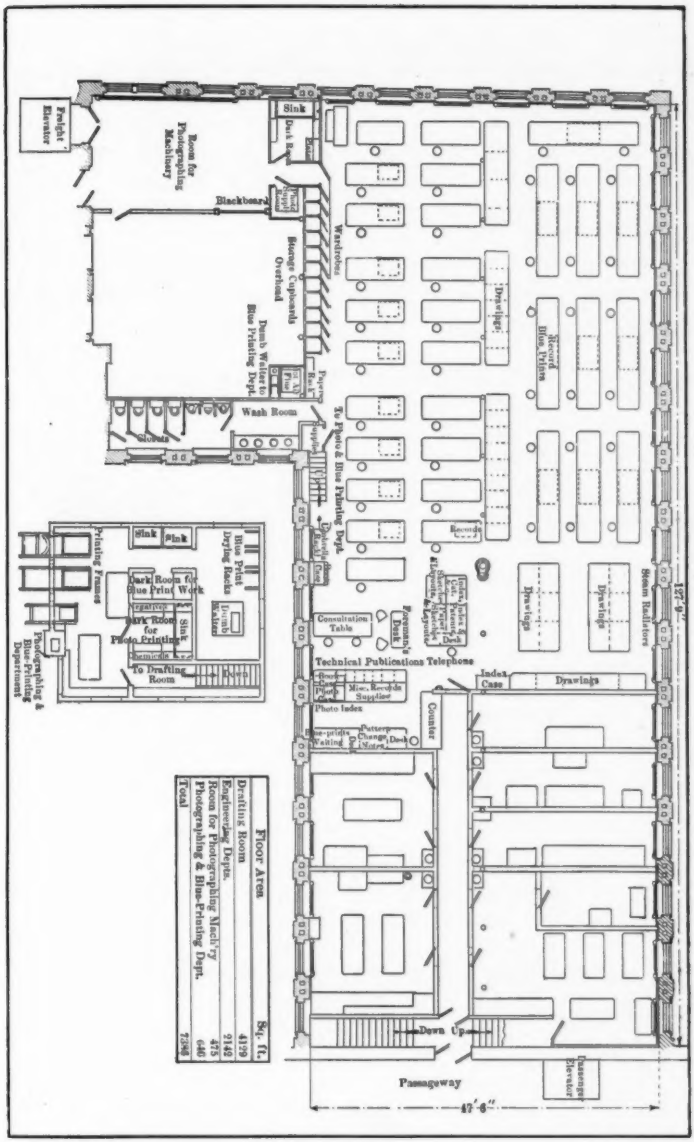
TO insure full success in any mechanical enterprise, at least two elements must be prominent: first, business and executive ability; second, engineering ability, including skill in manufacturing. What a business is in relation to its customers and the public, so, on a smaller scale—a circle within a circle—the drafting department is to the shop with which it is connected; and to secure the greatest efficiency, those elements necessary to the success of the business as a whole must be prominent in the management of the drafting department. I purpose in this paper to deal with these elements as factors in the successful management of the drafting department in its dealings with the shop.

One element of business success is to know the needs of the market; so the needs of the shop should be known in the drafting department. To accomplish this, these departments must be in close touch with each other. This makes it desirable to have the drafting room so located in the works that it will be in the midst of the shop work, easily accessible to the workman, and where the draftsmen can readily follow the work during its progress through the shop. Much of the business of the shop with the drafting department can be done over a wide counter at the entrance to the drafting room, with an electric call bell to signal such draftsmen as are often wanted. The draftsman should be ready to consult the shop man regarding all matters where his practical advice will be helpful. The shop man should

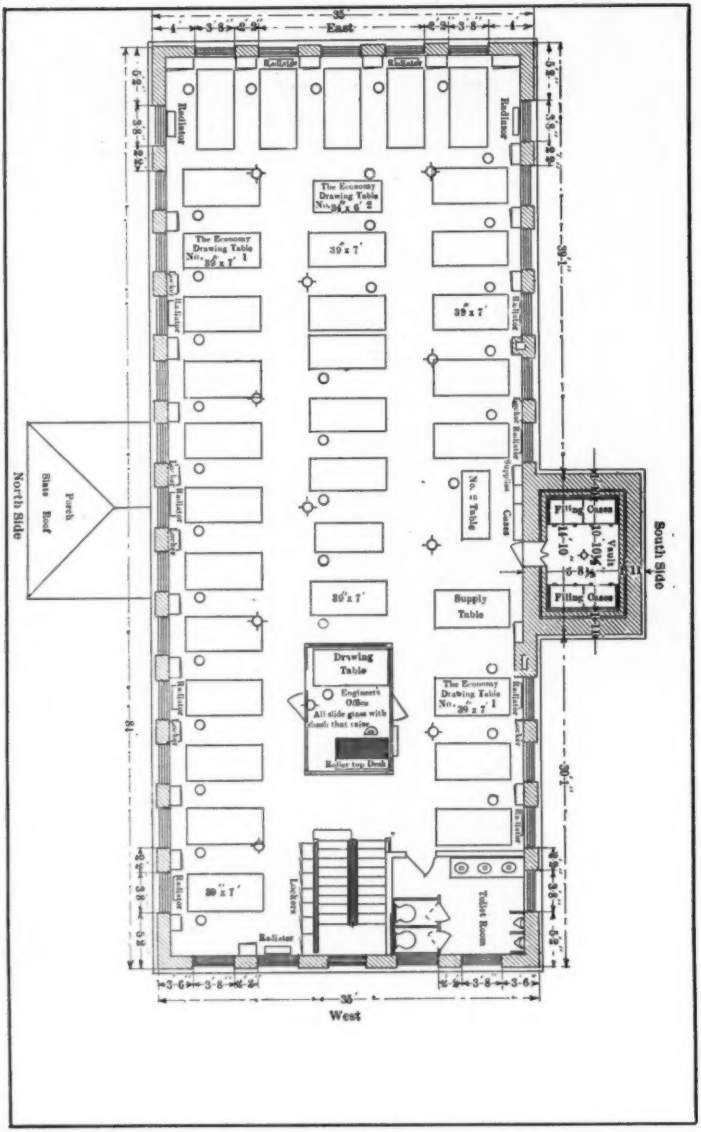


GENERAL PLAN, ENGINEERING AND DRAFTING DEPARTMENTS, WELLMAN-SEAVER-MORGAN CO., CLEVELAND, OHIO.

also be ready to point out difficulties and to make suggestions, not in a spirit of fault-finding and criticism but in a spirit of helpfulness. In all such dealings, the personal element should be entirely eliminated. It is a matter of satisfaction when questions can be considered on their merits and not degenerate into personalities, as is so likely to be the case. I remember when working over the drafting board as an apprentice, a question of design was under consideration, several men being in consultation at my board. I said, "Mr. ——— suggests such a method." One of those in consultation at once spoke up and said sarcastically, "Who is Mr. ———?" I began to explain but this man would not give the suggestion consideration because Mr. ——— held a subordinate position. This may be a glaring case but the same spirit keeps cropping up in one form or another, no matter how



ARRANGEMENT OF DRAFTING ROOM, BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.



DRAFTING ROOM, TOLEDO PLANT OF AMERICAN BRIDGE COMPANY.

vigilant the management of a shop may be to prevent it. The establishment where such a spirit starts at the top of the organization and permeates it throughout is in a bad way, indeed. Even if, owing to the genius of one man, it can hold together, it will topple and go to pieces as soon as he is gone. Consideration for others in the relations between the drafting department and the shop, between the departments of the shop, and between individuals, from the highest to the lowest, is given far too little attention as a factor in economical shop management. I have known good men, profitable to their employers, to leave their place of employment, not because of being underpaid but because of annoyances or misunderstandings with foremen or fellow workmen.

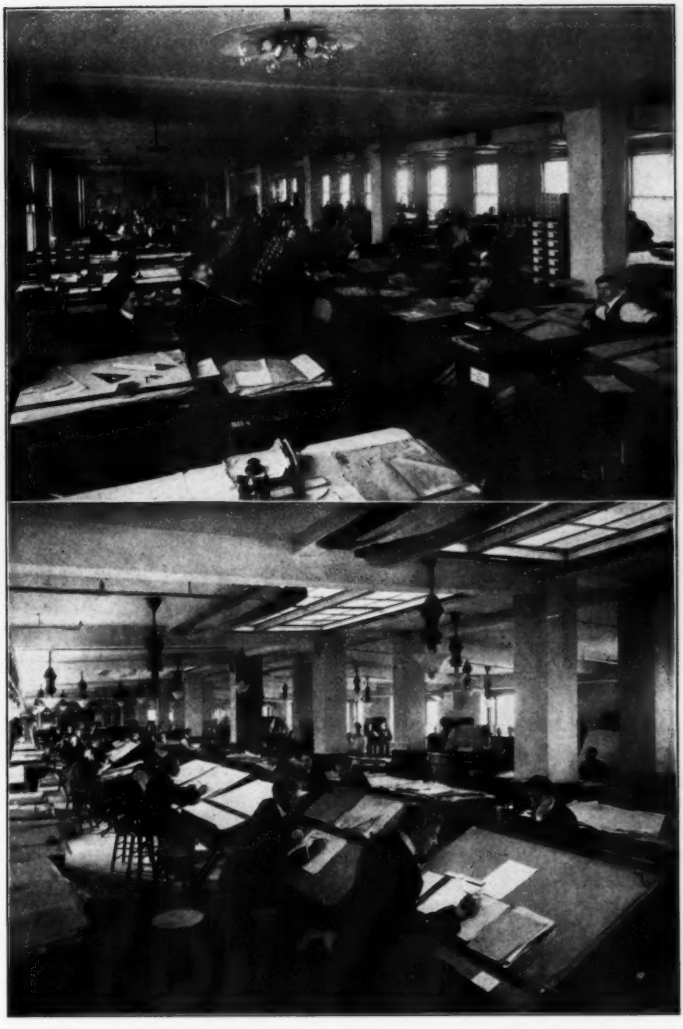
This leads me to the point that the cultivation of a spirit of courtesy among the workmen and their foremen will prevent petty tyrannies and jealousies, and will not only help to keep men contented, but will make them ready to give their employers and fellow workmen the full benefit of their experience and skill. At one time we had some large forging drawings returned to the works and the order-clerk, into whose hands they came, told his errand boy to "take them to Burnham" (one of the foremen). The boy looked in astonishment but upon a peremptory order, he went off with the drawings. We missed them a day or two later and upon inquiring of the boy, he said, "You told me to take them to burn 'um and I did it." In fact, he had taken those drawings to the boiler room and had them burned, all because the order-clerk forgot to use the "Mr." when giving his instructions. I do not wish to be misunderstood as saying that putting on the "Mr." makes all the difference. It is, however, the spirit of consideration lying back of it that helps to smooth over many hard places.

There are no departments between which there is more chance of a misunderstanding, resulting in friction, than between the drafting department and the shop. In order that the work of the drafting department may reach the highest efficiency and the designs be worked out with the greatest economy, every effort should be made, not only to preserve harmony in the relations between these two departments, but to benefit by the ideas and suggestions of the shop. Draftsmen who have had shop experience are perhaps more likely to appreciate the value of such help and supplement their own experience by that of the men actually doing the work. The draftsmen without shop training, needing such help most, are usually the last to avail themselves of it. In training apprentices in drafting, it is great help to them if shop work is made part of their regular instruction, giving them an insight into shop methods and requirements, experience in handling

tools, and thus a better conception of the labor-saving requirements of the shop. The Brown & Sharpe system of apprenticeship for draftsmen, as described in the January number of THE ENGINEERING MAGAZINE, has these objects in view. In many matters that come up for consideration in the drafting room, the machinist should not only be consulted but his judgment should have deciding weight. He is constantly with the work and knows where expensive fitting is required and where repairs are frequently needed; he appreciates where expenses can be reduced by the use of special tools.

THE DRAFTING ROOM OF THE BROWN & SHARPE CO., PROVIDENCE, R. I.

It is a problem to keep track of the many suggestions coming up, not only for improvements in design and for reduction of cost but for the correcting of errors or inconsistencies—suggestions that keep the draftsman always on the jump and disturb him in the midst of important work. While these are annoying, they are important, especially in a large establishment where machines are built in lots. A system in use at the Brown & Sharpe works tends to reduce this annoyance and interference with other work and at the same time to insure having all such points carefully attended to. Every foreman and responsible workman has a stub book in which he enters suggestions for such changes as seem desirable, and sends the notes to the drafting room. These notes are filed as they are received and



THE UPPER VIEW SHOWS THE DRAFTING ROOM IN THE EAST PITTSBURG WORKS OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. THE LOWER ONE IS THE DRAFTING DEPARTMENT IN BUILDING NO. 2, GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

CORNER OF DRAWING OFFICE, NEW WORKS OF MELDRUM BROS., LTD., TIMPERLEY, NEAR MANCHESTER.

Showing vertical drawing boards in use.

attended to collectively as each lot of machines is ordered. This system encourages mutual helpfulness between the workman and the shop and the drafting department, for it makes the men feel that their suggestions are given consideration. It also gives the draftsman suggestions helpful in his future work.

There is a great difference between so-called "red tape" and a thorough system carefully planned and perfected from time to time to suit it exactly to the needs. A shop manager recently told me that, in considering a drafting-room system, he drew the line short of one that required "an index of the index." There is an important truth here in a nut shell. Those that have had experience in systemizing work know how easy it is to lose sight of the main object to be attained, allowing it to become buried under the complications and expenses of the system, instead of being kept constantly in view. There are manufacturers who have had sad experiences with impractical or badly managed systems, and hence who denounce all systems as "red tape." A shop trying to run without system, however, is as much handicapped in competition with one well organized as a mob is against a trained army.

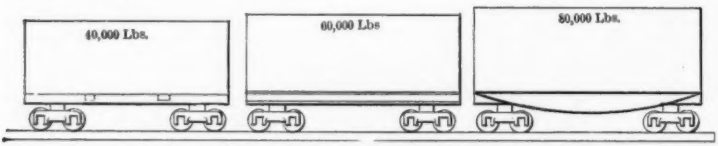
Any system to be efficient must be enforced. When the best

business judgment has determined on a system to be used, unless the executive authority works with it hand in hand to see that it is enforced, failure may result, no matter how good the system; and the system may be unjustly blamed. If impractical, the quicker it is known and abandoned the better. This end can best be reached by prompt enforcement. Gen. Grant has said, "I know of no method to secure the repeal of bad or obnoxious laws so effectual as their strict construction," and this is exactly applicable to shop systems.

Drawings should be followed: failure to follow them is one of the greatest causes of trouble between the two departments. If a drawing is wrong, it should be changed before the work proceeds; but the drawing should be authoritative and the workman should so understand it. It will be helpful in carrying out this plan if the draftsman is willing and prompt to make such necessary changes and corrections as are suggested, leaving no excuse on this score for work to proceed contrary to the drawings. Modern practice requires that the drawing shall be made complete, all parts fully detailed with full instructions. It is desirable to have standard work detailed with one piece on a sheet so that the drawing may accompany the work through

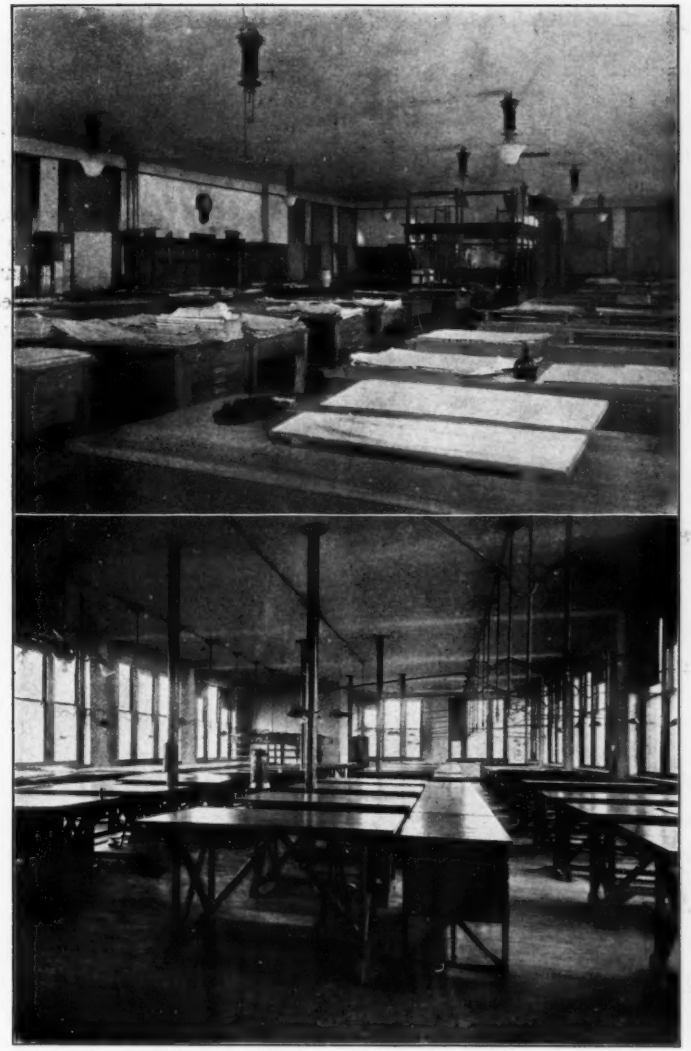
GENERAL DRAFTING ROOM IN THE WORKS OF MESSRS. GRAHAM, MORTON & CO., LEEDS.

all departments. Special books, containing lists of tools that are in use about the works, such as taps and reamers, should be available in every department of the shop; also lists of all screws and small parts carried in stock. Complete records of this sort reduce the amount of information necessary to give on the drawings. It is important that there be a distinct division of authority. It shows trouble at the fountain head, when, after errors and delays have occurred, each man concerned says, "I did not know I was expected to look after that." Somebody is responsible, and the division of responsibility should be so clearly understood beforehand that there can be no such excuse.



AN ILLUSTRATION OF MODERN PROGRESS IN ENGINEERING.

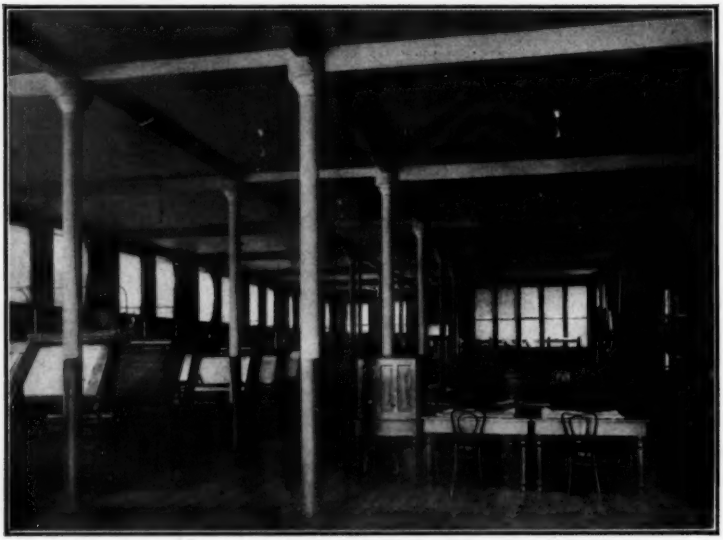
So far I have shown some of the ways in which the business and executive handling of the drafting room can increase its efficiency by making shop skill and experience more available. Engineering ability is an equally important factor, and a progressive spirit in the engineering department is necessary to keep up with the march of events. I saw a good illustration of this a short time ago, when waiting for a train at a way station. On a siding stood a train of freight cars and of the three directly before me coupled together, one was marked 40,000-pounds capacity, having old fashioned wooden beams above the trucks; the next one, having 60,000-pounds capacity, had steel I beams; and the third car had trussed supports, giving a capacity of 80,000 pounds. Here were the old and new, illustrating the great steps of progress during the last few years and suggesting the engineering possibilities of the future. Engineering and shop skill may, in exceptional cases, be attained by intuition and by a process of learning from the top down; even in the best of such cases the path is strewn with expensive mistakes due to lack of experience and immature judgment. In fact, all experience is made up in some measure by learning, through one's own mistakes and the mistakes of others, what *not* to do. The well established and safe way is to begin at the bottom and work up by patient and long continued study and experience gained by actually performing the operations in the shop—in the foundry, the smith shop, and the various departments of the machine shop. Even the specialist needs to be a broadly trained man, especially when he is working alone and dependent wholly on his



ABOVE IS THE DRAFTING ROOM, TOLEDO PLANT OF THE AMERICAN BRIDGE CO.; BELOW, THAT OF THE PITTSBURG OFFICE OF THE M°CLINTIC-MARSHALL CONSTRUCTION CO.

The American Bridge Co. room has the upper sash of all windows filled with factory ribbed glass; artificial lighting is by eleven lamps. There are practically no shadows, and the inner tables are almost as light as the outer. The McClintic-Marshall room is characterized by high ceilings and adjustable electric lights at every table; walls and ceilings are light blue, aiding in reflection and diffusion of light. Rear left corner of each room is a fireproof vault for storage of tracings.

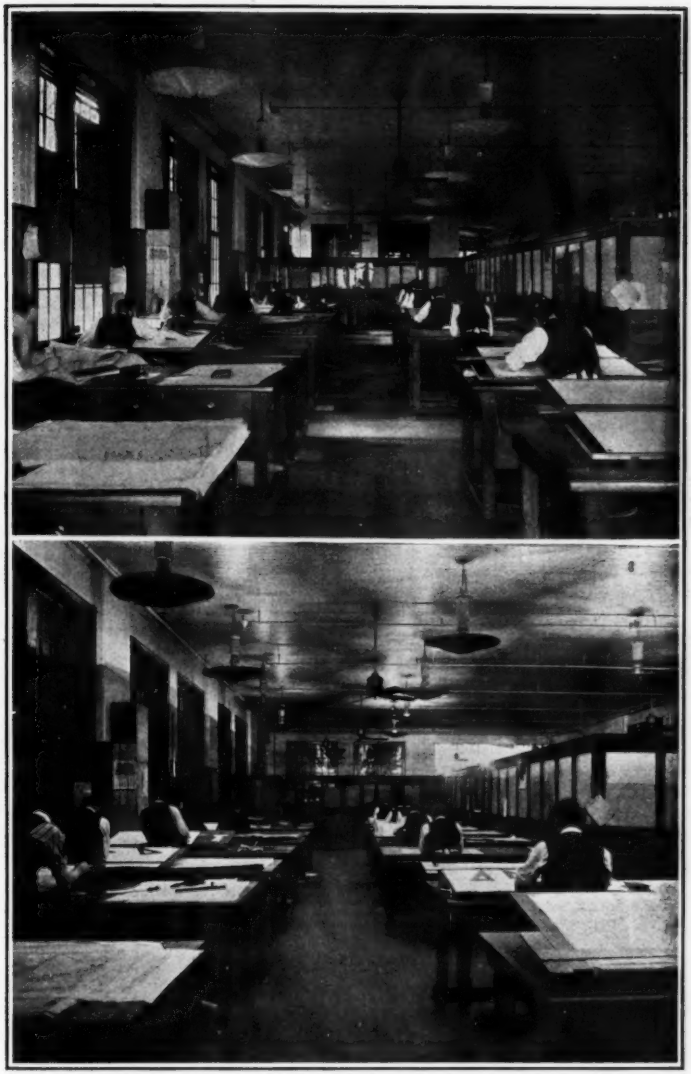
own resources. In a large engineering department, the organization may be such that at least one man is expert in each of the main branches of mechanical work. The force should include technical men (the more practical the better) to help in applying theoretical problems to everyday work, and practical men (the more theoretical the better) to apply the test of experience to the problems that may arise and to puncture many a bubble of fallacy as soon as it is blown. My experience has been that the best help on technical problems arising in the shop has been given by practical men who have obtained their technical training self-taught, through long years of finding out, as the needs arose, how to do things. I do not say this in disparagement of the technical schools—they are doing a good work—but simply to point out that school work does not take the place of real experience.



DRAFTING ROOM, THE WELLMAN-SEAVER-MORGAN CO., CLEVELAND, OHIO.

The chief draftsman under whom I learned the trade, said that if he were to train a boy as a draftsman, in seven years of preparation he would give him four years in the shop and three in the drafting room. Many of the best draftsmen have had extended experience in the shop. The work of pattern inspector gives the draftsman a good understanding of pattern and foundry work, both of value.

It is a common failing of humanity that "familiarity breeds contempt." When, on close acquaintance, it is found that the shop man



THE TWO VIEWS OF THE DRAFTING ROOM OF THE LINK-BELT ENGINEERING CO., SHOWING EFFECTS OF LIGHTING.

The upper picture was taken by daylight, the lower by artificial light. The light is thrown up against the ceiling by reflectors, and the diffused reflection thus secured gives a very uniform illumination.

THE DRAFTING ROOM OF THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.

does not know some things the draftsman knows, because perhaps his spelling or grammar may be at fault, it is not a sufficient reason why the draftsman should despise his opinion and advice. When the draftsman comes to the machinist or shop foreman with a question or suggestion showing lack of shop knowledge, it is a short-sighted man who will jump to the conclusion that because this draftsman does not know some particular point which the machinist has learned by experience, therefore he knows nothing. A broad-minded, helpful spirit on both sides will lead in time not to contempt but to mutual confidence and reliance. I sat in our State House a few days ago during a session of the legislature in company with our general foreman, and after witnessing a stormy session, showing both energy and ability on the part of the legislators, I asked him how he would like to run a machine shop with that force of men. The look he gave me was significant; no words were needed. It was not necessarily a reflection on the men before us either; it simply recognized the difference, the incongruity of expecting one man to do another's work.

The man in the shop may laugh at a new boy from the drafting room, when, having been cautioned at home to be sure to keep away from the machines so that he would not get hurt, he edges away, with his coat gathered closely about him, from a machine that is not belted up and cannot run. The draftsman has to restrain his smile also when suggestions of perpetual motion and of kindred nature are proposed to him in the shop. It is a clear-headed man in either department that in the discussion of ways and means or the working out of complicated mechanisms always avoids such pitfalls. Conference between the two departments often shows up such fallacies. Explaining a design so clearly that others can understand it prevents them from creeping in.

There is a tendency in the shop to look with favor on the "Rough and Readies"—the Zachary Taylors of the shop, with their blunt ways and quick understanding of the requirements, and with distrust on the "fuss and feathers"—the Winfield Scotts, who are more for form and system but who may be just as useful and display even greater ability. This feeling has to be taken into account when dealing with workmen, and the recognition of it helps many a designer to get valuable information and help, by fraternizing with the men of the shop in their own way.

If a draftsman asks himself certain questions about each design or drawing he makes or checks before it leaves his hands, much shop criticism may be avoided. Among such questions are these:

Are there sufficient clearances and no interferences?

Are the castings so designed as to be readily moulded?

Can parts be practically machined; can they be assembled?

Are the worms, clutches, etc., the correct hand to give the required direction?

Are the necessary figures all given, and are they so given as to be of most help to the workman?

These may not be exactly engineering questions, but neglecting them may result in engineering failures. There are certain methods used in drafting, conventional ways of showing things, that the shop man should know as part of the A B C's of his calling. He cannot intelligently work from drawings unless he can read them. A failure to understand some of these simple rules may lead to the spoiling of expensive work; the cutting of clutch teeth the wrong hand, the turning down of a shaft where it is meant to be flattened only, and other like mistakes. That the workman may not be misled, the draftsman should employ uniform methods throughout his work.

A wide and varied experience covering engineering work, shop work, foundry and pattern work, architectural work, and patent-office work, can hardly be expected to be highly developed in one man. Among the advertisements in our mechanical papers for help, about all of these lines of experience have been called for in one man and he must be a young man at that. The advertiser, moreover, sometimes expects to get such help for little more than journeyman's wages. When employers have such distorted ideas, they are in danger of getting very superficial help. Stability is a quality of great value in a drafting-room force—long enough service in one place to have become familiar with its needs and to have insured such confidence as to be entrusted with responsible work. Draftsmen, as a class, have the reputation of being wanderers. They think they are broadening their experience; in reality they are becoming superficial, and do not stay long enough in one place to be entrusted with such work as to give them the best experience. Whatever, in the management of a shop, tends to develop a permanent force helps to increase its efficiency. At the Brown & Sharpe works the average length of service in the drafting and designing departments, a force numbering over fifty men, is more than nine years each with this one concern, the records of some of these men being nearly forty years. Some idea can be formed of what an amount of stored-up experience this means when it is realized that it is a total of over five hundred years of experience, directly on the work of this company, in addition to the many years of experience some of these men have had in other places. Such a stored-up experience has great potential value as a factor in conducting a successful business.

MECHANICAL AIDS IN FACTORY-OFFICE ECONOMY.

By George Harvey Seward.

Modern business methods, requiring both mental and mechanical operations on a very large scale, have opened an opportunity for the introduction of labor-saving machinery in commercial as well as shop management. There has, however, been little attempt at any comprehensive or systematic review of progress in this line, sufficient to acquaint the manager with the various devices available for his uses. The purpose of this article and the second paper by Mr. Seward which is to follow, is to point out the directions and extent to which mechanical aids may be advantageously used in the factory office, and to give an impartial summary—necessarily brief, but intended to be as complete as conditions permit—of the whole field.—THE EDITORS.

OFFICE work on a large scale, in its division and subdivision into departments, very much resembles factory production; each employee has only a small, unrelated portion of the work to perform. Consequently a great volume of detail in office operations is practically reduced to a factory basis; in fact, it is a question in the larger offices as to just how so simple a matter as that of making records shall be done, and every effort tends toward mechanical production. This is illustrated by the use of blanks, carefully prepared so that a minimum amount of labor is required to make the necessary record, which may be in the form of check-mark or by actual mechanical operation, such as the perforation of a card. It is eminently proper, therefore, that we consider the use that is made of mechanical aids in a factory office.

Office routine should be such as to produce a conscientious effort; therefore mechanical aids can have a moral as well as practical use, as they place responsibility where it belongs, eliminating that element which does so much to lower the efficiency of an office—friction. As an illustration of this, consider the effect a time stamp has upon an em-

ployee who is responsible for the passage of certain papers through the department in which his duties fall.

Factory-office economy is the term I have chosen into which to focus the various elements entering into the conduct of a highly organized and well-equipped, non-productive or commercial department of a factory. The present discussion will not take up non-mechanical elements. It is matters of a dynamic rather than a static nature with which we are concerned.

Specifically, the term "factory-office economy" is intended to cover the regulation of the use of appliances and materials and the provision for those conveniences and conditions which will produce the highest efficiency. A portion of our subject is included in the well-known classification of human knowledge known throughout the bibliographical world as Dewey's Decimal Classification. Class 600 of this work is *Useful Arts,* and subclass 650, *Communication and Commerce,* which in its division into nine sub-divisions, has for its first, "Office Equipment and Methods."

So far as I have been able to learn, no serious attempt has been made to subdivide 651—Office Equipment—as the other classes have been, thus indicating in some degree the state of our knowledge of the subject. I have substituted the term "office economy" for office equipment that it may include a broader field. The subject of mechanical aids in a factory office falls under the seventh division, Appliances, of the subject of office economy in a suggestive classification* proposed by me, which is further subdivided as follows:—

651.70 Appliances.
.71
.72 Mathematical Aids. Calculators.
.73 Time Appliances.
.74 Dating, Numbering, and Pricing Machines.
.75 Registering and Tabulating Devices.
.76 Graphic Aids, Charts, Routing Systems.
.77 Protective and Perforating Appliances.
.78 Mail-Room Apparatus (Addressers, etc.).
.79 Communicative Systems (Telephone, etc.).

The present article will deal with mathematical and time appliances, leaving the remaining mechanical aids for review in a succeeding paper.

Mathematical Aids.—The introduction of such modern accounting devices as card and loose-sheet systems has created a large field for mathematical aids in factory office computations. An adding machine for example, helps to develop the labor-saving features of a

* Author's suggestions only; not intended as authorized schedules for Dewey's Decimal Classification.

system of records by cards or loose sheets. Addition, indeed, makes up about 95 per cent. of all the accounting work required in a factory.

Computing machines can be used further in combined operations such as balancing and averaging accounts, discount, and computations in which a number of products are added together and the sum divided by the number of items. Such devices, it is estimated, save one-third of the mental and physical energy expended in writing. Great use for them is found in the auditing, sales, treasurer's, paymaster's, cashier's, cost, and shipping departments of factory offices, in taking trial balances, making up bank-deposit slips, balancing cash, verifying postings, making up pay rolls or sales reports, taking inventories, listing freight bills, making out monthly statements, compiling statistical work, etc.

With the aid of one of these machines an employee's efficiency is increased two or three fold, as he not only gets out more and better work, but he can do it in one-fifth the time, so he has extra hours every day which he can devote to more important matters. And these appliances further permit the use of young, unskilled help, while they yet retain a large proportion of the accuracy of high-salaried office assistants. They are thus altogether in harmony with the trend of practice in the machine shop and in manufacturing generally.

An elaborate mechanical classification of calculating machines has been adopted by the United States Patent Office for the 824 issues made (up to May 23, 1904). From the viewpoint of the user, however, a much simpler classification may be made, which is:—

1.—Listing machines, which are practically adding machines performing other operations only in a round-about way.

2.—Non-listing devices, which include:

a. Slide rules.
b. Stylus operated devices.
c. Key operated devices.
d. Crank machines for large computations.

Listing Machines.—Where the items to be added are drawn off from some record in book, sheet, or card form, it is often desirable to have a list of them as they are added up by the machine, and a reliable adding machine is as much a necessity in the modern office as is the typewriter. It adds and lists forty items per minute. Typical of this class are the Burroughs, the Comptograph, the Universal, and the Standard machines.

The amounts listed may be printed either on a narrow ribbon of paper or on a separate sheet like a page in a loose-leaf ledger.

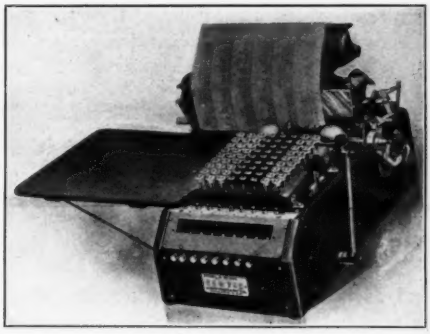
BURROUGHS' "ARITHMOMETER," ADDING AND LISTING MACHINE.

Two original ink copies of the record can be made from one ribbon and one set of type on the Comptograph.

In operating a listing machine all that is necessary is to press the keys representing the amounts to be added and move a lever. The amounts are thereby listed and accumulated in the machine, and whenever desired a total can be printed by simply pressing the "total" button and moving the lever. If the operator at any time is interrupted in his work, he can attend to other matters and continue his addition where he left off, as the amounts will be retained in the machine. The majority of these machines are used for listing and adding money items, but machines are also made to add feet and inches, tons and hundredweight, hours and minutes, fractions, etc.

The Addograph is a machine used in combination with an adding machine to bring together its work and that of a typewriting machine by one operation—the nine numeral keys of the typewriter setting the eighty-one numeral keys of the adding machine. The added record is made in the adding machine and the total copied on the type-

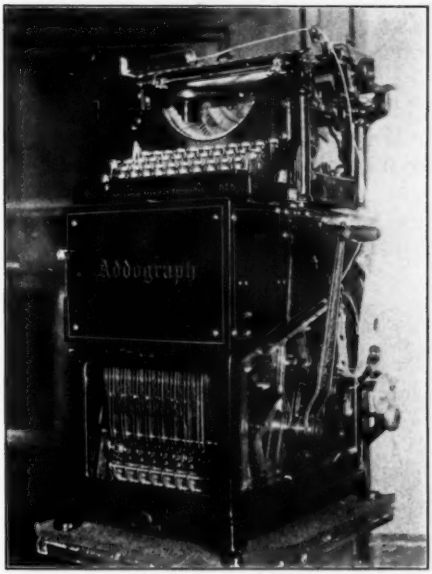
writer. The typewriting machine is available at all times for correspondence or other work ordinarily required of such devices. This combination machine is useful for writing invoice and sales-book records by one operation.



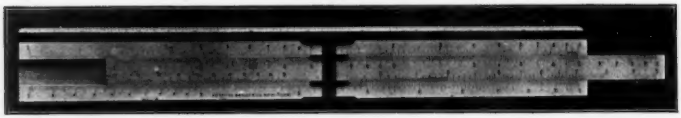
THE COMPTOGRAPH

Non-Listing Machines.—The difficulty of adding items on different sheets or cards without recapitulating them is manifest. With a machine that will add, but not necessarily list the items, they are added as easily as though they stood in a column on a sheet. Postings to a card or sheet record are checked by running the postings through a machine before the cards or sheets are filed, to ascertain if the total from the original record agrees with the total of the posted amounts.

Slide Rules.—The applications of the slide rule are as general as the fundamental rules of arithmetic. It is useful to the mechanician engaged in problems involving any of the mechanical powers, in finding the pitch and proper number of teeth, the diameter of toothed wheels, in designing machinery and in ascertaining its power. Commercially, it is useful in extending pay-rolls, pro-rating accounts, for ascertaining the weight of metals and other materials, and in the general application of multiplication, division, proportion, fractions and as a check on ordinary calculations.



NATIONAL ADDOGRAPH.



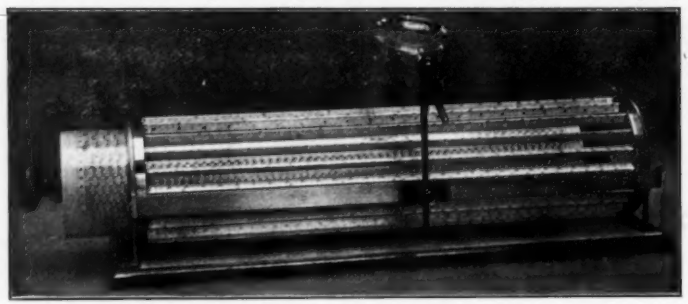
THE SLIDE RULE.

It consists of a geometrical scale of logarithms, so arranged that operations may be performed by sliding one part upon another and reading off the result graphically displayed.

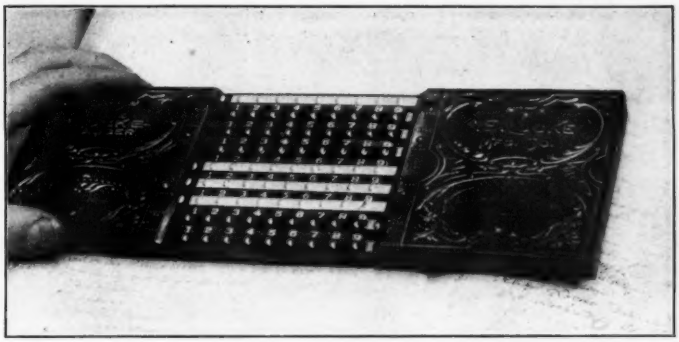
The Thatcher instrument consists of a cylinder 4 inches in diameter and 18 inches long, upon which the logarithmic scales are arranged in twenty parallel lines; the cylinder revolves within and upon a framework composed of twenty angular bars. The logarithmic scale is duplicated on the exposed sides of the bars, and a proper movement of the cylinder allows any of its graduations to be brought into coincidence with any graduation on any bar.

The Omnimetre is a circular modification of the slide rule printed on concentric cards, which is very convenient of manipulation and adapted to a broad range of mathematical operations. This tvpe of circular slide rule is the form known in the patent office as single-axis calculators. Prominent among inventors of these calculators is Carl G. Barth of Swarthmore, Pa., who has devised slide rules on which very complex mathematical problems may be solved. Of the twelve variables that enter into the problem of determining the most economical way in which to remove a required amount of stock from a piece of lathe work, all but a single one—the stiffness of the work—are incorporated in the slide rule.

The Locke Adder is a type of bar calculator. Different sliding bars represent various orders in the decimal notation, the lowest and nearest side being units, the next hundreds, and so on. The adder is operated by placing the fingers upon the knobs opposite the proper



THE THATCHER MACHINE.



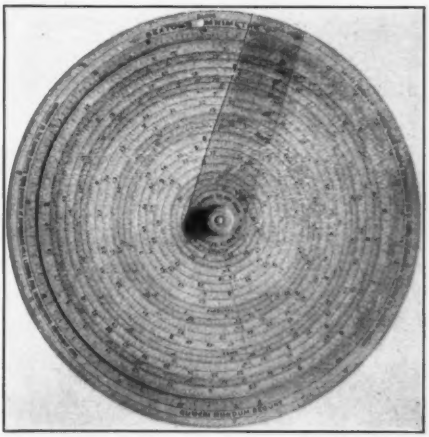
THE LOCKE ADDER.

figures and moving them to the right or left until stopped by the edge of the plate. The resultant figures are read down or towards the operator. The size of the device is about 4 by 11 by ½ inches.

A device known as the "Calcumeter" consists of a number of movable dials that can be rotated underneath a perforated plate bearing a series of stationary dials. In using the machine, it is placed conveniently near the column of figures to be added; then the units, tens, and hundreds of the first amount are registered by bringing the proper dials around with a stylus. The next amount is treated in the same manner, the machine carrying the units to tens, tens to hundreds, etc. Other dial machines are Herring's and Webb's.

The New Idea calculator is designed to exhibit ready-made multiplications occurring in payroll and labor-cost sheets.

The Arithmachine is a belt type of calculator in which endless chains in contact with numeral disks are operated by a stylus. This ingenious device, the invention of Henry Goldman, is operated for addition by depressing, by the stylus, at the proper point, the chain in the column corresponding to power



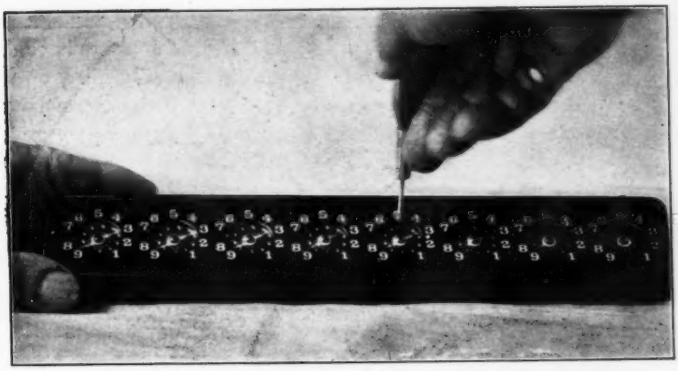
SEXTON'S OMNIMETRE. (CIRCULAR SLIDE RULE.)

of the figures to be registered, and drawing the chain forward. The operation is similar to making a figure "1" on paper. The device is 4½ by 1½ by ¾ inches.

The Beach machine is a compact device for addition, principally, occupying a space of about 42 square inches. The total registration of the first model is $999,999.99. Complemental figures are provided for subtraction and division.

THE NEW IDEA CALCULATOR.

The Comptometer is a key-operated machine for performing the four basic mathematical operations. On account of the large proportion of adding and multiplication in arithmetical operations, the keyboard is arranged to facilitate these operations. It is disposed decimally, the units from one to nine being in the first column, the tens from ten to ninety in the second, and so on. Addition is performed by simply depressing the keys bearing on their tops the numbers to be added. To add 568, a "five" key in the third column, a "six" key in the second column, and an "eight" in the units column are depressed, and 568 appears in the register. Multiplication is performed by taking one number on the keys and in striking it the num-



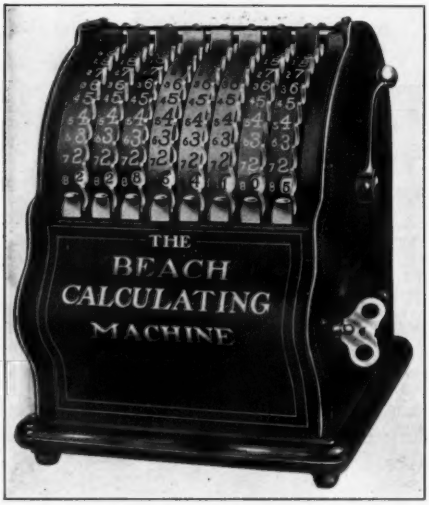
THE CALCUMETER.

ber of times indicated by the figures of the other number in their proper position on the keyboard. On the new model any number of keys in the multiplier may be struck simultaneously. By means of complementary figures on the keys division and subtraction are performed.

The Mechanical Accountant is a combination of keys and dials and is key-operated. An original feature is a set of dials, in addition to the usual registering ones, which is operated simultaneously by the keys and indicates the particular key struck, thus enabling the operator to prove his work as he goes along. The size of the device is 13 by 8 by 6 inches; capacity $9,999,999.99.

Crank Machines.—A few years ago the use of this type of calculating machines in the United States was limited to life-insurance companies. Now their utility is being recognized in the great in-

GOLDMAN'S ARITHMACHINE.



BEACH CALCULATING MACHINE.

dustrial corporations so that importers have difficulty in keeping up with the demand. In Europe they are in quite general use. Their use by every individual clerk is not recommended so much as that by such employees as are able to review the transactions of the day intelligently, to prove their correctness.

These machines are especially applicable to large work and are beginning to have a commercial use where there is work requiring a large amount of multiplication. Machines of this type, except the Baldwin, are at present imported into the United States, and are

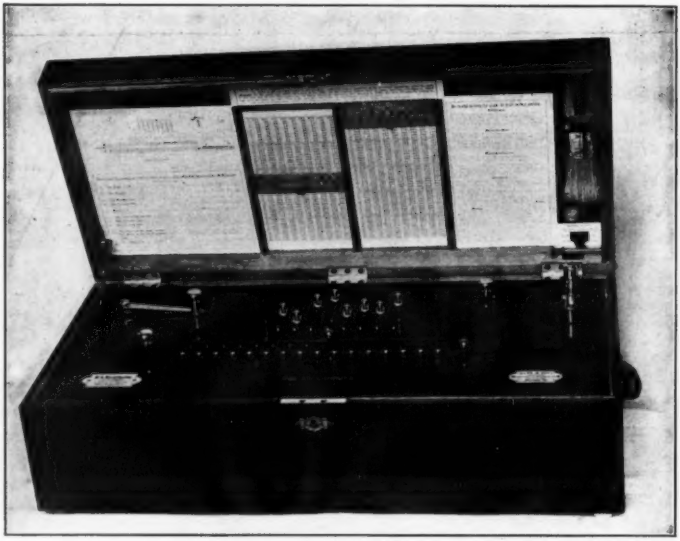
COMPTOMETERS IN USE IN THE OFFICE OF THE ALBERT DICKINSON SEED CO., CHICAGO.

known as arithmometers or reckoning machines. Multiplication is performed step by step, using a multiplier of one figure. On most of the machines the crank handle is turned the number of times corresponding to the multiplier. To multiply by eight, for example, the handle would be turned around eight times. Different forms of these machines are:—Thomas, Odhner, Tate, Burkhardt, and Millionaire.

The Baldwin calculator is an American machine, the invention of Frank S. Baldwin, of Newark, N. J., who has been engaged in the manufacture of similar machines for over twenty years, taking out letters patent in 1875. His present machine is made under patents granted to him in 1902. It is 10 by 7 by 6 inches, has eight numeral wheels, nine figures in the quotient, and sixteen in the product.

THE MECHANICAL ACCOUNTANT.

The "Millionaire" Calculating Machine requires but one revolution of the crank handle to perform an operation. To multiply by 8, for example, a pointer is set for the multiplicand, another for the multiplier, and the crank revolved once. In a similar way division, addition, and subtraction are performed. As an illustration of the utility of this and other machines of it may be cited that it is used in the structural department of a steel company, principally in carrying out multiplication of quantities on lists of items of structural steel taken from drawings. A machine operator carries out and adds the totals on lists made by two or three other men, saving the work of one man in four or five. On more simple routine work in the same place the machine does the



THE MILLIONAIRE CALCULATING MACHINE.

work of at least two men using the customary logarithmic or multiplication tables. The Burkhardt machine is sold in three sizes.

Registers of various types, including those for recording cash sales, and tabulating machines, have adding mechanisms but will not be treated under this heading of mathematical aids.

Time Systems.—Time measurement is undoubtedly the most important element in factory-office economy. As the factory records of time measurement are sent directly to the office, appliances may be

BURKHARDT'S CALCULATING MACHINE.

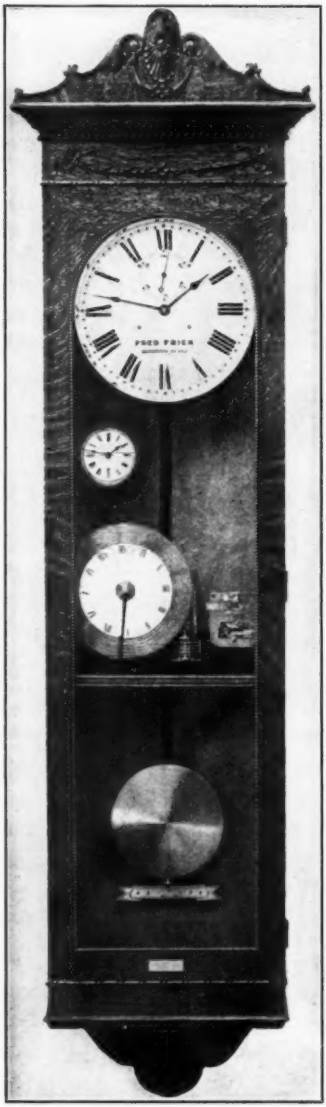
discussed in the broad sense independent of their location in the plant.

Up to 1890 there was no automatic system of time keeping employed. The old brass-check system had been used for checking men in and out of work. There was the old-fashioned timekeeper perched on a stool, pad in hand, who attempted to check the workmen as they passed through the entrance. He was sometimes late himself, and had his friends who were never docked. There was no check on mistakes, whether made honestly or through favoritism or collusion, and the employer had no evidence to offer in case of disputes. Today no argument is necessary to convince a factory manager that a time recorder is an essential part of the plant equipment. The only real question is the kind that should be adopted. During the past two or three years an additional use has been given to time recorders, and a largely increasing interest and value is now attached to time recorders in factories for determining the cost of production.

					Line total
1 245.51	6 419.91	2 251.65	471.86	1 759.21	12 148.14
1 311.32	194.12	615.62	5 666.52	2 965.76	10 753.34
3 292.63	1 465.45	1 214.56	121.46	1 656.12	7 750.22
311.22	1 264.26	1 221.42	519.23	646.76	3 962.89
3 381.60	62.97	673.24	9 186.16	2 376.23	15 680.20
1 231.92	74.53	1 212.32	8 475.65	1 713.51	12 707.93
5 843.50	262.62	4 623.43	1 235.44	671.26	12 636.25
1 456.42	158.56	552.86	437.61	1 436.11	4 041.56
1 527.68	1 275.64	2 425.61	556.45	3 767.00	9 552.38
7 560.52	2 263.12	1 336.23	581.59	1 128.12	12 869.58
1 318.26	2 545.63	212.42	656.93	5 468.92	10 202.16
2 655.23	4 621.65	2 746.45	625.32	1 139.63	11 788.28
6 311.46	7 622.14	664.12	1 381.25	7 642.91	23 621.88
			Total----	147 714.81	147 714.81

FAC-SIMILE OF A RECORD FROM THE COMPTOGRAPH.

The study of "unit times" is cited by Mr. Taylor as the first detail of importance in making any factory system a success. He commenced in 1883 to time with a stop watch each of the elements of the various kinds of work done in a machine shop, and then found the quickest time in which each job could be done by summing up the total times of its components parts. Afterwards he established a time-study and rate-fixing department to give out piece-work prices. Mr. S. E. Thompson of Newton Highlands, Mass., devised a watch-book and watch dial, first for himself and then for Mr. Taylor. He says that comparatively few, even at this date, realizes the absolute necessity for taking observations upon the elementary units into which operations can be divided. Even when using decimal watches and watch-books they continually neglect the necessary sub-division, and take the gross observations, so that their results are valuable only for the specific job under observation.



FRICK'S PROGRAMME CLOCK.

There are three methods of control of time appliances—mechanical, electrical, and pneumatic. The mechanical, or gravity, time device is necessarily a unit by itself, while electrical and pneumatic appliances may form a system, all the devices connected in unison and operated from a master clock.

Time devices are used for at least five different classes of work at a plant—coming-and-going, cost work, dating of papers, signaling (programme apparatus), and record of movement of watchmen. Every factory of any size has some method of keeping a record of the time each employee spends in the works. With checks, cards, and pass books for time-keeping purposes we are not concerned.

Of practical time recorders for the first two classes there are:—

(1) Key, (2) Autographic, (3) Dial and Drum, (4) Card, (5) Calculating.

Key Recorders.—With this form of recorder (for coming and going time), each employee has a numbered key with which he registers his time and number by inserting the key in the recorder.

Autograph Recorder. — For a small number of employees, the registration of their names and time is accomplished, when records in this form are desirable, by an autograph recorder.

Dial-Recorders.—For the drum-dial time registers it is claimed; (1), that the record is so arranged

6	45	56
6	49	25
6	55	98
7	1	87
7	4	124
★ 12	1	98
★ 12	2	87

FAC-SIMILE RECORD OF KEY RECORDER.

that confusion is impossible, since for each man a separate line opposite his assigned number is provided; (2), that these numbers being consecutive, a workman may make his record without reference to the man who has preceded or is to follow him. Registrations of six, twelve, or forty-two records may be had, the latter for an entire week. Where only two registrations daily are required, the recorder of twelve registrations, will, of course, last an entire week. Automatic adjustment of the "In and Out" mechanism is provided when men come and go at fixed hours.

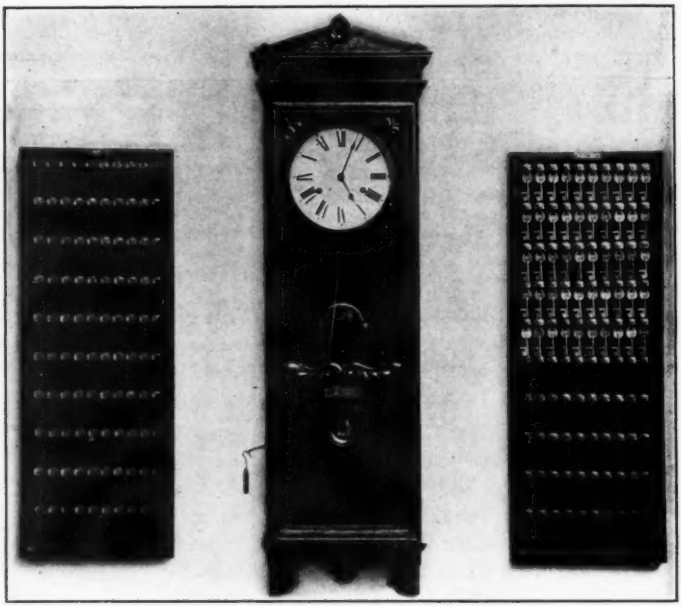
For conditions where it is inconvenient for the time clerk to remain until the last employee has left, or to be on hand before the first employee arrives in the morning, a double drum is provided. The change of record on a register so equipped may be made the day following that for which the record was made. The machine itself changes from the first pay day, e. g. Monday, to Tuesday and registers the arrival of the employee on the Tuesday slip. To record the time of both night and day shifts, two slips are put on the drums; the latter being close together, the last registration for Monday night is alongside the first registration for Tuesday morning, so that the record for Monday and Monday night are on the Monday slip and those for Tuesday and Tuesday night are on the slip for that day.

Two-color ribbons are used to distinguish between the records of those who arrive at the proper time and those who are late, or between day and night shifts. The change is made automatically.

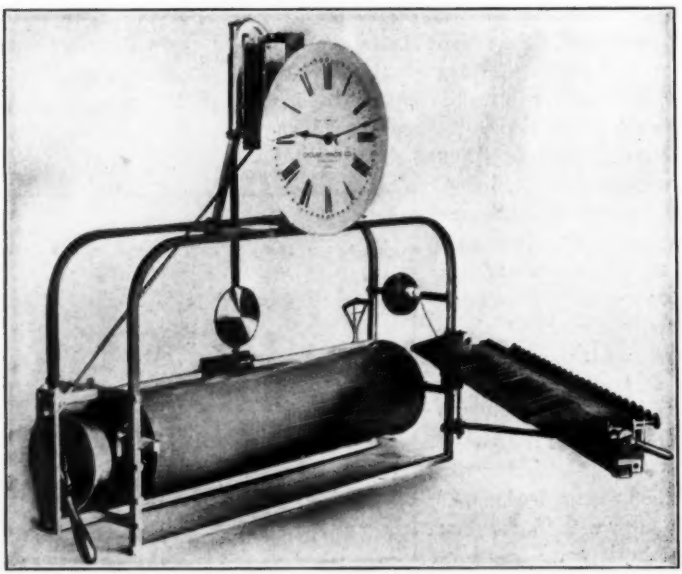
A drum register employing sensitized paper upon which individual markers trace continuous lines during the

C. Fisher	7	57
Ed. Snyder	7	58
H. J. Morgan	8	01
C Fisher	12	01
Ed Snyder	12	03
H. J. Morgan	12	03

FAC-SIMILE RECORD OF AUTOGRAPHIC RECORDER.

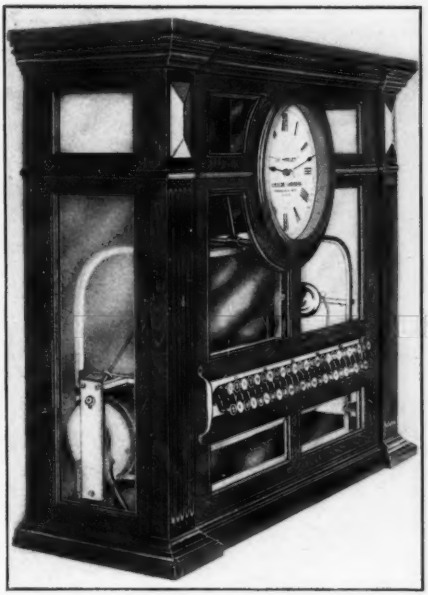


BUNDY KEY RECORDER.



INTERIOR MECHANISM OF THE HAWLEY TIME REGISTER.

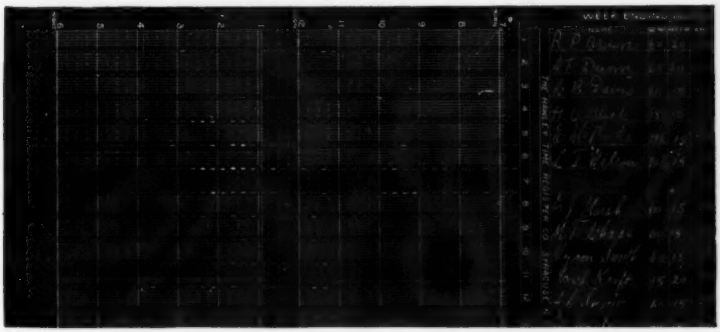
measurement of a time period has recently come upon the market. Clock mechanism controls the revolution of the drum so as have an inch on the surface (upon which the sensitized paper is wrapped) equal an hour.



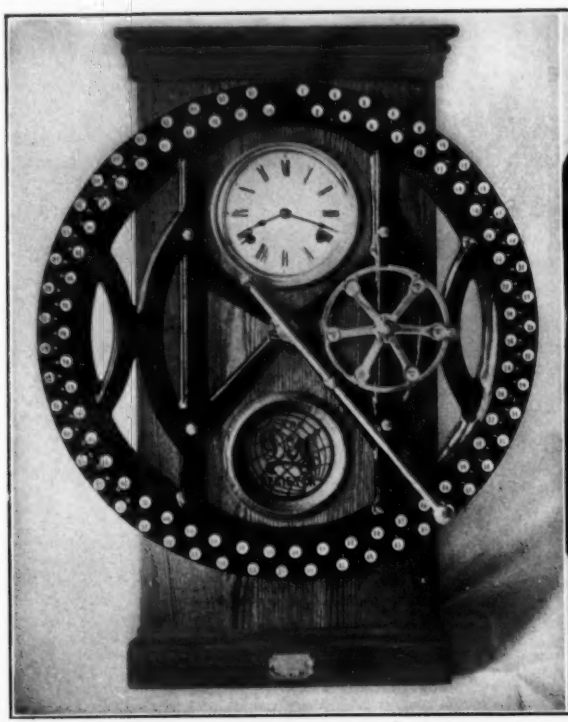
HAWLEY TIME REGISTER.

Card Recorder.—The card recorder furnishes a system of keeping all kinds of time of employees. As the record is on a card outside of the clock it can be utilized with all the advantages of the card system. The operation of recording is simple and well-known. On the back of the card may be entered piece work or distribution of time on a job, concentrating at one point all details of each employee. Each kind of piece work or time spent on different orders can be entered, so that it only needs adding up at the end of the week to balance against the time recorded on the face of the card, thus saving a great amount of clerical work.

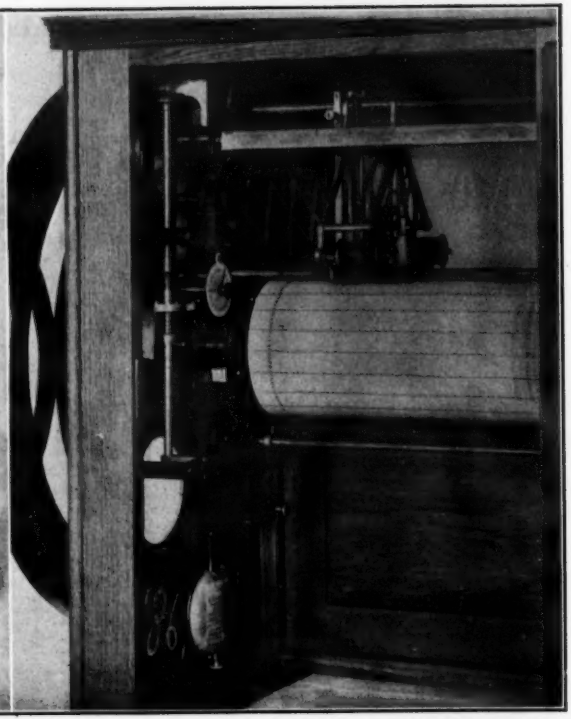
In making up the pay roll the totals only from the cards are en-



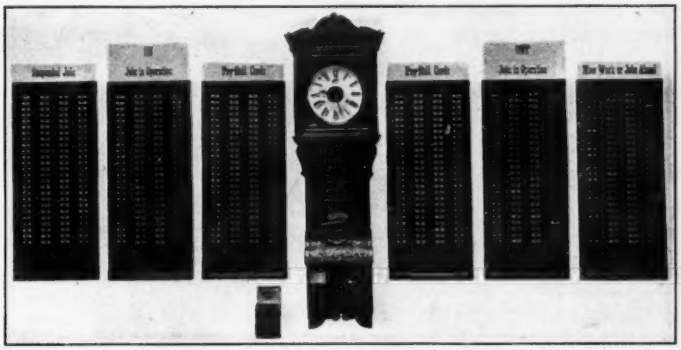
FAC-SIMILE OF SENSITIZED PAPER RECORD FROM HAWLEY TIME REGISTER.



DEY TIME REGISTER COMPANY'S DRUM-DIAL TIME REGISTER.



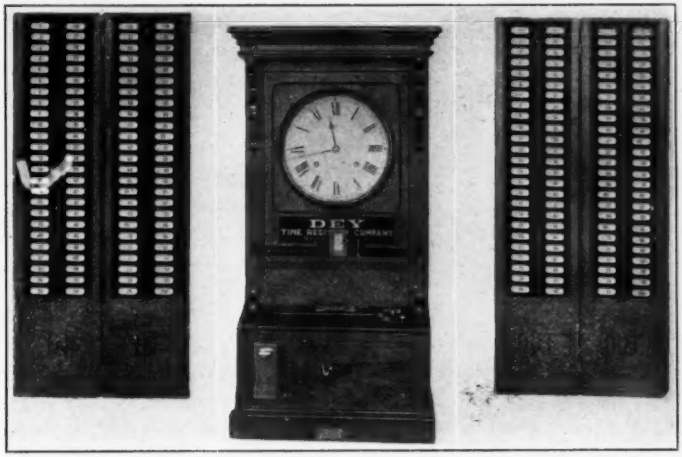
INTERIOR DEY AUTOMATIC WEEKLY DRUM-DIAL TIME REGISTER.



ROCHESTER CARD RECORDER AND RACKS ARRANGED FOR COST KEEPING.

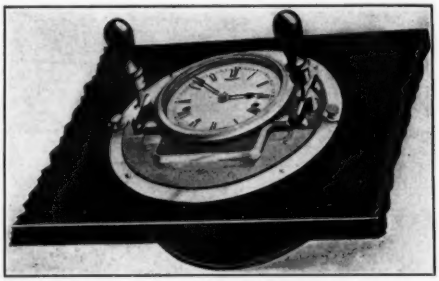
tered, thus enabling a pay roll for one hundred employees, for example, to be made up in less than an hour each week.

For cost-keeping purposes, the card recorder is admittedly the best. Separate cards are employed, on which the time is recorded for each job or operation connected therewith. These cost cards are checked with the weekly time cards and this comparison exposes any errors, loss of time, or false distribution. The reasons for the adoption of a card recorder by a factory manager are given as; (1), prevention of alteration of the registered time; (2), opportunity for the employee to note personally his arrivals and departures for an entire



DEY CARD RECORDER.

week, so as to calculate his own time, if he so desires; and (3), the abandonment of the system of daily transfer of time to the individual payroll book or sheet with its liability of error and expense of transfer.



THE CALCULAGRAPH

The recorder is placed in a central position on each floor of a factory or in each department, so as to be accessible to every employee without material loss of time in recording his time as he changes from one job or operation to another. The foreman performs the little clerical work required to fill out the cards when the employee begins the work. The workman has no clerical work to do; he simply registers his time when commencing and finishing the work called for on the card. The total time on these cost cards should equal his coming-and-going time recorded on his weekly time card for that day. If it does not, some explanation is expected from the foreman by the executive to whom the records are submitted. This card system of time recording is applicable to the work of the shipper, tool makers, sub-foremen, and cleaners, who may have single cost cards for an entire week. It may be arranged for piece work, premium plan, or day work. A device that gives not only the time of commencing and finishing but prints the elapsed time in hours and moments, as well as the time of day at either end of the period, is known as the Calculagraph. This appliance was originally brought out for use in timing the length of long-distance telephone calls. It has found a field, however, in the factory for cost-keeping purposes, a card being used for the record. The card is pushed into the slot of the device at the commencement of the job or operation, a lever operated, and then withdrawn until the completion

INTERNATIONAL TIME STAMP.

of the work when it is again inserted in the device and the other lever operated. The operation of the first lever prints the dials, which are connected with the arrows and revolved in chronological unison with the time-keeping mechanism of the clock. By operating the second lever the arrows only are printed. Dials and arrows being in chronological unison, the impression of each at separate times will show how far the combination has traveled in the interval between operations of levers (beginning and finishing of time period under measurement) or the elapsed time. Contrary to initial impressions of those looking into the merits of the device, it can be used by any number of employees.

WEEK ENDING MAY 30 1903 190

No. 154

NAME. W. H. Harding

DAY	MORNING IN	MORNING OUT	AFTERNOON IN	AFTERNOON OUT	EXTRA IN	EXTRA OUT	
MON.	M6 55	M12 01	M12 56	M6 01			
TUE.	T6 58	T12 05	T12 57	T6 11			
WED.	W6 59	W12 01	W12 58	W3 30			-2½
THU.	T6 58	T12 05	T12 57	T6 08	T6 58	T10 02	+3
FRI.	F7 36	F12 04					-5½
SAT.	S6 57	S12 06	S1 01	S6 02			
SUN.							

TOTAL TIME 5.5 HRS.

RATE 32½ PER HR.

TOTAL WAGES FOR WEEK, $ 17 88

FAC-SIMILE OF CARD USED IN THE INTERNATIONAL ROCHESTER RECORDER. ONE-HALF SIZE.

The use of time appliances for the dating of papers, signalling by programme clocks, and the recording of the movements of watchmen, are interesting applications but space forbids their description.

In a following number of this Magazine the author will discuss succeeding divisions of Appliances as given in outline on page 606. He will be glad to answer any inquiries.

A BIBLIOGRAPHY OF WORKS MANAGEMENT.

By Hugo Diemer.

With an Editorial Introduction, and an Index to the Current Literature of the Subject Prepared by the Editors of THE ENGINEERING MAGAZINE.

WRITING in our Works Management Number (January, 1901), Mr. James N. Gunn spoke of "Industrial Engineering"—to use the broader term which he prefers—as "a science which only awaits the creation of a literature to have its own existence recognized as a new department of engineering." We are tempted to amend this dictum slightly by substituting "collation" for "creation." The creation of the literature has gone hand-in-hand with the development of the profession, and both have grown to meet the requirements of the evolution of manufacturing. It is the pride of THE ENGINEERING MAGAZINE that it has been foremost in recognizing the new field of engineering enterprise, and in presenting to the profession some of the most important contributions to its literature.

We are glad, therefore, to present in the following pages what is probably the first systematic attempt to catalogue and review all the important works upon the subject, permanent and fugitive. The result is not supposed, by either author or editors, to be complete. As pioneers, we meet the difficulties of covering a field which is untraversed—indeed, not very certainly delimited. It is perhaps a reconnoissance rather than a survey. It will be enough if the work is sound, and provides a solid basis for further elaboration. The books are arranged generally in the order of their appearance, as this plan best displays the evolution of the science.

The author wishes us to say that the notes of the books by Charles Babbage, Sedley Taylor, N. P. Gilman, and Messrs. Sinclair and Frank Pearn, were editorially prepared, the works in question not being readily accessible to Mr. Diemer. We acknowledge further our obligations to our friends—especially to Mr. James N. Gunn—for the suggestion of authorities. The index to the current literature which follows Mr. Diemer's review of the more permanent works was prepared by the editors, most of the work of compilation being performed by Mr. J. H. Cuntz.—THE EDITORS.

THE application of scientific methods to the investigation of problems of factory management has resulted in the accumulation of a bibliography of considerable extent having to do wholly with these questions. Fundamental pre-requisites or accompaniments to the study of such a bibliography are the three branches of learning in which he who would train himself for the profession of works management should be thoroughly grounded, namely, engineering, accounting, and economics. It is noteworthy that the authors of the works hereafter referred to have been, almost without exception, engineers, who have added to their technical training and experience the essential knowledge of accounting and of economics, requisite to a comprehensive grasp of the problems of factory management.

The ambitious engine tender has at hand several works of more or less merit on the steam engine. He is a subscriber to some technical or trade paper from which he gains advice and inspiration. The same is true of the first-class pattern maker and draftsman, and of any high-grade craftsman. The chief engineer and the master mechanic of a large industrial establishment usually have at hand a supply of high-class works of reference. It seems singular that the same should not be generally true of commercial managers, or of engineers who have been drawn into positions of works management. To be sure, the literature of factory economics is not abundant. Yet there have been some very good works published. A reading knowledge of some of these works would frequently be of great value to managers and their assistants in charge of departments. Such a knowledge might often result in the anticipation of plans and methods which would otherwise require years to mature. That this is true is evidenced by the frequent reproduction, in the most elementary form, of methods thought new and original by those introducing them, when in fact the same methods have been far more completely worked out by others. A similar ignorance of current practice and of best methods on the part of the mechanical and engineering staff, would be considered unpardonable.

A certain evidence of the lack of reading along these lines by those who might profit therefrom, is the ease with which an unscrupulous man who has made himself familiar with the literature of works management is able to palm off, as originated by himself, charts, tables and forms, and sometimes pages of discussion, copied verbatim from standard works. It certainly would be a profitable investment for many a manufacturing corporation to provide a reference library of such standard works as would be of particular application to and

bear upon the business concerned, and to encourage the staff to make use of this reference library in and out of working hours.

In the following list of literature, there has been an intentional omission of such works as have been written on factory problems, the factory system, etc., by theoretic sociologists without practical experience, and also of works dealing generally with the science of economics in its political and sociological aspects, with but slight and incidental treatment of the economics of industry.

In reviewing the works, the endeavor has been made to find what particular feature has been the author's specialty. Naturally each writer, if he is a man of practical experience, will have made a special investigation of some particular branch. The emphasizing in the review of what this specialty appears to be, it is hoped, will assist in the selection of such papers or books as are particularly applicable to certain work in hand. The arrangement of the works briefly reviewed in this discussion will be chronological.

The earliest, and in many respects the most remarkable book relating to manufacturing problems is a small work written more than fifty years ago by the eminent engineer and mathematician, Charles Babbage. This work, which is now very rare, is entitled:—

1.—On the Economy of Machinery and Manufactures; by Charles Babbage, Esq. A. M.; London, Charles Knight; and Philadelphia, Carey and Lea, 1832. The latter is a reprint of the original English edition, and it is from this reprint, in the library of the American Society of Mechanical Engineers, that this notice has been prepared.

Mr. Babbage, in the course of his work upon his various forms of mechanical calculating machines, was impressed with the close relation of the use of machinery to various economic problems, and in this little book, of fewer than 300 duodecimo pages, he treats of questions, which, at the early date at which he wrote, were scarcely in existence, and which even now are rarely grasped with the clearness with which he discussed them.

After examining the sources of the advantages arising from the use of machinery in manufactures, together with the mechanical problems involved in the control, regulation, and application of power, he proceeds to discuss such subjects as the registering of operations, and the determination of the identity of work and its accuracy, in a way which might be studied to advantage to-day. Having obtained his information by the exercise of his keen powers of observation upon the occasions when he was permitted to examine factories then in operation, Mr. Babbage inserts an interesting chapter upon the

method of observing manufactories, including a set of forms upon which inquiries might be made and replies noted, this forming an excellent indication of the thoroughness of his own researches. He then examines, quite in the modern mass-production method, the difference between making and manufacturing, following this study by comments upon the influence of verification and inspection upon costs, together with some hints as to the importance of considering the fluctuations of prices as measured by money in making comparisons between processes at different times. He proceeds to discuss the advantages of the division of labor, both physical and mental, and then examines the importance of determining the separate costs of each process in a manufacture, a subject which is even yet but imperfectly understood and still less perfectly practised.

There are chapters upon the reasons for the establishment of large factories, and some wise advice to those who may be considering the location of such establishments, together with a caution in regard to over-production, and hints upon the condition under which mechanical methods may properly be introduced. Although the book was written long before the present great combinations of labor organizations, or of trusts and employers' combinations, it contains chapters with the suggestive titles: "On Combination amongst Masters or Workmen against Each Other"; and "On Combination of Masters against the Public"; and these, and indeed nearly all the chapters of the little book, appear to have been written almost in a prophetic vein.

When it is considered that this work was written but a short time after the establishment of the factory system in England, and before railways had been commercially undertaken at all, it is a most remarkable production; and the fact that nothing more was produced upon the subject for more than fifty years indicates the extent to which the ideas of Babbage were in advance of those of his contemporaries.

The second work in the list, appearing long after Babbage, was:—

2.—Profit Sharing between Capital and Labour; Six Essays; by Sedley Taylor, M. A. To which is added a Memorandum on the Industrial Partnership at the Whitwood Collieries (1865-1874), by Archibald Briggs and Henry Currer Briggs. London, Kegan Paul, Trench & Co., 1884. Pp. xiii—170.

These essays give an account of the work of the French house-painter Leclaire, who, in 1842 started a co-operative system from which the present methods of profit sharing in France have developed. It also includes a description of the work of the society established in 1879 to promote the study of the system and to extend its use.

The essays include: Profit sharing in the Maison Leclaire, Profit Sharing in Industry, Profit Sharing in the Paris and Orleans Railway Company, Profit Sharing in Agriculture, and Profit Sharing in Distributive Enterprise; these all relating to applications in French industry. The Briggs memorandum describes the practical operation of the experiment in profit sharing at the Whitwood Colliery between 1865 and 1874.

3.—"The Depreciation of Factories, and Their Valuation"; by Ewing Matheson; published by E. & F. N. Spon in 1884.

This work is of great value in demonstrating the principles involved in the scientific handling of problems of inventorying and appraising. The book contains five chapters on "Depreciation" and eight chapters on "Valuation." It is written in an easy-flowing, clear style. A general discussion of depreciation, why and how it is used in accounting, is followed by division of the plant into various classes, and a discussion of the depreciation applicable to each class. Some examples follow, and also a very complete table showing the effects of depreciation at different rates for different periods of time—a valuable aid in appraisal work. Tables are also given showing the accumulation of a reserve fund with compound interest in a term of years, and how much must be invested annually as a sinking fund to accumulate a certain amount in a given terms of years. In regard to the matter of valuation, a full discussion is given of the many conditions which will affect valuations. The author discusses the valuation of a business as a whole, and of the factory buildings and plant. A new edition has lately been issued.

4.—"The Cost of Manufactures and the Administration of Work-Shops"; by Captain Henry Metcalfe, Ordnance Department, U. S. A.; published by John Wiley & Sons, the first edition having been printed in 1885.

This is an exhaustive and elaborate treatise on the order, stock-room, and cost-accounting methods employed in arsenal work. The author, at the close of the work, gives a list of such parts of the treatise as he considers general in their application. In an introductory chapter certain very sane and pertinent statements are made as to the art of administration, and its dependence upon the application of certain principles which make up what may be called the science of administration. In arguing that men intrusted with executive positions be freed from burdensome details, he says: "There is a certain economy of attention by which the more active a man's work, the less is he capable of contemplation. Foreman's heads may be put to

better purposes than having to bear a constant burden of solicitude about clerical work."

The main body of the work is devoted to a description and criticism of old systems of arsenal accounting (which will be found even today to correspond to methods used in many shops), together with the results of the author's study in devising better methods of organization and accounting. The card system is used throughout, and the author illustrates every form used; filled in, in almost every case, as they would be in actual work.

An appendix, added to later editions, consists of a paper by the author on "The Shop-Order System of Accounts," delivered before the American Society of Mechanical Engineers, in May, 1886.

The most distinctive features of the work and of the appendix are a thorough discussion of the individual-operation order slip, or service card, which, together with the material card, form the basis of the cost-accounting system. The distribution of indirect expenses is not taken up very fully.

5.—"Factory Accounts"; by Emile Garcke and J. M. Fells; Crosby, Lockwood & Son, 1887.

In a preface the authors state that their aim has been to show that as great a degree of accuracy can be attained in factory book keeping as in commercial accounts.

The authors make a clear statement of the distinction between materials for manufacture and articles complete in the manufactured state. Until materials are converted into finished products of sale, they are spoken of as "Stores," but when so converted, they are termed "Stock." The accounts in the "Prime Cost Ledger" are debited with wages and materials spent in manufacture and are credited with the stock produced. Of 264 pages, 148 are devoted to descriptions of methods of accounting. The remainder of the volume consists of appendices, composed largely of British Factory and Work-Shop Acts.

The most meritorious part of the work is that which has to do with Stock and Stores accounting. The methods described for time keeping, pay-roll accounting, and piece-rate analysis so-called, have been much improved by later practice.

The authors show in complete detail a system of requisitions, purchase orders, and stores accounting records, by means of which double-entry balances may be kept on stores. The principles of the system are sound. A competent store keeper or purchasing agent should find no difficulty in adapting the ideas of the authors to the requirements of the particular business with which he is connected.

In the matter of cost accounting, the authors state:

> "It is not only important to know the cost of each individual article produced, but equally so to ascertain the cost of any particular part or of any particular process of manufacture. Localization of cost should be carried as far as possible, so that the varying rates of realizable profit on parts may be known, and the pressure to minimize cost of production be applied in the right direction."

The matter of labor costs and distribution of indirect expenses has not been worked out as fully as the stores problem. The double-entry balance principle is carried still further into a method of balancing the manufactured stock ledger acccounts with the commercial ledger. Charts built up of circles and arrows and tracing the relationships of forms and accounts, serve to simplify the schemes proposed, and to make clear the underlying principles.

6.—"Engineering Estimates, Costs and Accounts"; by A General Manager; Crosby, Lockwood & Sons, 1889.

This work is intended primarily as an aid to persons called upon to make estimates of costs of manufacture. There are some parts of the work that contain matter of considerable suggestive value to those having to do with running cost accounts. Several chapters are devoted to a discussion of methods of rapidly estimating quantities of material and time required for labor. A chapter on indirect expenses and their departmental distribution, although short, contains sound principles which may be applied to advantage in a further expansion of this important phase of manufacturing accounts. A great number of specific examples of estimates follow, covering almost every class of machine-shop and millwright work. The last chapter is devoted to costs' book keeping. Here again the best part of the discussion is that having to do with indirect expenses. A criticism of the methods described would be that there are too many bound volumes, many of which would be better replaced by loose-leaf or card systems. Again, dependence is made upon the workmen themselves for entries of labor, and upon records of store-room boys as to material consumed, without any check as to correctness of such draft at the time of issuing stores. The value of the book is in its discussion of the process and methods of estimating, rather than in any contribution to the science of cost keeping.

7.—"Gain Sharing"; a paper by Henry R. Towne; presented at the May 1889 meeting of the American Society of Mechanical Engineers.

This paper, and several others, will be listed among the books reviewed, since these papers well deserve the name of classics.

> "Webster defines profit as excess of value over cost, and gain as that which is obtained as an advantage. I have availed of this well-expressed though delicate distinction between the two terms, to coin a name for the system herein described, whereby to differentiate it from profit sharing as ordinarily understood and practiced. The right solution of this problem will manifestly consist in allotting to each member of the organization an interest in that portion of the profit fund which is or may be affected by his individual efforts or skill, and in protecting this interest against diminution resulting from the errors of others or other extraneous causes not under his control. Such a solution, while not simple, is attainable under many circumstances, and attainable by methods which experience has shown to be both practical and successful."

The plan advocated by Mr. Towne is the differentiating of all items affecting cost of production over which the operatives have any control whatever, and offering the operatives a share, say one-half, of any reduction per unit of product that they may be able to bring about in these items in the course of a year. Foremen and other responsible heads are to receive a larger pro rata share of the saving effected than the rank and file.

Mr. Towne presents tables showing the operation of the system for two years at the Yale and Towne Works. It is interesting to note that the company has discontinued the plan.

The discussion by Mr. E. F. C. Davis is the first record published of the so-called premium plan. He cites an instance of a friend of his who announced to his workmen that he would allow a definite number of hours to do a certain machine-shop job, and that of any time the workman saved over that, he would get one-half the benefit. Mr. Davis stated that after the workmen found that the offer was really made in good faith, the plan worked very well.

8.—Profit Sharing between Employer and Employee.—A study in the Evolution of the Wage System; by Nicholas Paine Gilman; New York and Boston; Houghton, Mifflin & Co., 1889. Pp. x-460.

A comprehensive review of the entire subject, discussing various forms of wage systems, followed by some account of the work of Leclaire in France and its extension on the Continent. There are chapters on profit sharing in transportation, distribution, and agriculture, together with historical and practical discussions of profit sharing in England and in the United States. A critical summary and analysis of experience in profit sharing is given, followed by a bibliography of the subject, including twenty-eight titles of books and pamphlets in English, French, and German, and references to articles upon the subject in periodicals. In "A Dividend to Labor. A Study of Employés' Welfare Institutions." (Houghton, Mifflin & Co., 1899; pp.

vi—400) the same author treats especially of welfare associations operated in connection with manufacturinng establishments, including clubs, libraries, relief departments, pension systems, etc. Some attention is also given to profit sharing, bringing the author's previous work down to date. There is a bibliography appended, extending down to 1899 the one given in the author's book on profit sharing.

9.—"The Premium Plan of Paying for Labor"; a paper by F. A. Halsey; presented at the June, 1891, meeting of the American Society of Mechanical Engineers.

Mr. Halsey briefly outlines the advantages and disadvantages of the day-work plan, the piece-work plan, and the profit-sharing plan, and then describes the premium plan as used by himself, citing specific instances illustrating the working of the method. "Under the day-work system, matters settle down to an easy-going pace, and the employer pays extravagantly for his product." With regard to piece work, Mr. Halsey discusses at length the evils of rate cutting. He presents as an objection to the piece-work plan an argument that may in many cases be a strong one in its favor, namely that it requires a knowledge and record of the cost of each piece of a complicated machine, and often-times of each operation on each piece, thus limiting its application to products which are produced in considerable quantities.

With regard to profit sharing, he objects that any system of profit distribution based on collective rather than individual efforts is unfair, that the remoteness of the reward is a disadvantage, that in bad business years there will be no distribution, and that the workmen have no check on the correctness of the employers' figures.

With regard to the premium system, he advocates varied hourly premium rates for time gained, depending on the character of the work, a detail that deserves more attention than it has generally received.

In the discussion, Mr. William Kent attests to the fact that Mr. Halsey spoke to him about the premium plan a year or so prior to Mr. Towne's discussion on gain sharing. Mr. Kent introduced the method at that time in the shops of the Springer Torsion Balance Company.

10.—"A Piece-Rate System"; by Fred W. Taylor; a paper presented at the June, 1895, meeting of the American Society of Mechanical Engineers.

In this paper, Mr. Taylor presents the first recorded recommendations in favor of a careful or scientific study of the subject of rate fix-

ing, and of the differential piece rate. Piece-work prices based on elementary rate fixing differ from such prices as usually made, in that a careful study is made of the elemental times required to do each of the constituent steps into which the manufacturing operations of an establishment may be analyzed. These elementary operations are then classified, recorded, and indexed, and when a piece-work price is wanted for work, the job is first divided into its elementary operations, and the total time for the job is summed up from these elementary data.

The differential-rate system of piece work consists of the offering of two different rates for the same job—a high price per piece in case the work is finished in the shortest possible time, and in perfect condition, and a lower price per piece if it takes a longer time to do the job, or if there are any imperfections in the work.

Mr. Taylor expresses it as his opinion, based on extensive experience, that the workmen in nearly every trade can and will materially increase their present output per day, providing they are assured of a permanent larger return for their time than they have been receiving, and that employers can well afford to pay higher wages per piece, even permanently, provided each man and machine in the establishment turns out a proportionately larger amount of work.

The most formidable obstacle to the solution of the piece-work problem, Mr. Taylor states, is the lack of knowledge of the quickest time in which each piece of work can be done, the remedy for this lying in the establishment in every factory of a proper rate-fixing department.

In closing the discussion of his paper, Mr. Taylor expressed regret that the elementary rate-fixing features of the system he described did not receive more attention by the members discussing his paper, and stated it as his firm conviction that this question must occupy more and more of the attention of manufacturers in the future.

This paper of Mr. Taylor's, together with his later and exhaustive one delivered at the June, 1903, meeting (an abstract of which is given in this bibliography), deserve the most careful perusal of every manufacturer. The author's statements regarding elementary rate fixing are enunciations of broad general principles which, no doubt, have been applied by other successful managers, and it is only narrow mindedness that will prevent careful study of his papers on the ground that they have been a source of profit to the gentlemen exploiting so-called "systems" based on these same broad principles of industrial management.

11.—"The Commercial Organization of Factories"; by J. Slater Lewis; E. & F. N. Spon, 1896.

Mr. Lewis's comprehensive work of 540 7 by 10 pages, deals with administration, organization, and accounting. The fact that a specific system is traced through the work with elaboration of its minutest details, makes the work one that requires the closest sort of application and study in order that one may get from it the principles generally applicable. Much attention is devoted to strictly commercial office accounting.

To Mr. Lewis belongs the credit of making a very full exposition of the important subject of the proper distribution of establishment charges, as he calls them, or expense accounts as generally designated in America. Chapter XXIII of the work devotes seventeen pages to a thorough treatment of this subject, which is carried out even more fully in Chapter XXXIV, on "Works and Job Office," in which the "Standing Order" system is also explained.

Mr. Lewis makes use of the chart method of circles and arrows as previously employed by Garcke and Fells, in illustrating the connection between the accounts and forms illustrated. He also carries the chart system a step further to illustrate the staff organization of the factory.

12.—"The Commercial Management of Engineering Works"; by Francis G. Burton; The Scientific Publishing Co., Manchester, 1898.

As the author states in his preface, this work is intended primarily for young engineers. Its object is to present to these young men the problems that are likely to confront them, when commercial duties are thrust upon them, and to offer suggestions that may be of assistance. The work does not claim to represent the results of any scientific research in any special field of factory-organization or administration. "Engineering Estimates and Cost Accounts" is an earlier book by the same author.

13.—"The Management of Engineering Work Shops"; by Arthur H. Barker; The Technical Publishing Co., Limited, Manchester, 1899.

Mr. Barker's book bears throughout the impress of the practical shop man. It is free from pedantry, original in expression, and independent in attitude. It is not so much a book of detailed commercial accounting forms as a collection of principles and experiences. Of 208 pages, 140 are devoted to topics dealing with factory arrangement, equipment, and administration. The remaining 68 pages are devoted to the subject of costs. The portions of the work devoted to the drawing office, and the tool equipment of the shops, are practical and de-

tailed. The system of drawing-office control of all orders is advocated throughout.

> "There must be a definite routine in the issuing of all orders, and the meaning of them must be perfectly clear. The workman, be he draftsman, clerk, or mechanic, who knows exactly what he has to do, will do the work in half the time that he will occupy if he has first to find out what is wanted. This principle cannot be too strongly insisted on. It is impossible for anyone to work vigorously if he has only a hazy conception of what he has to do. Loosely worded or incomplete instructions are responsible for a greater waste of money than anything else, without exception."

The classification of establishment costs is also thoroughly treated.

> "The subject of establishment costs naturally divides itself into two parts, (1) the reckoning up and classifying of the amount actually spent in keeping up the establishment during each year, (2) the division of this total amount among the various orders executed in the shop. If it were possible to wait till the end of the year before making this division, the problem would be very much simplified. In practice, however, the final cost of the article has to be got at within a very short time of the completion of the order. To keep the establishment accounts correctly is a highly complex piece of book keeping. The cost-keeper to be really efficient must be not only a trained engineer, but must have a very thorough knowledge of book keeping, and these two qualifications are very rarely combined. The objection of many firms to the proper distribution of establishment costs is the more surprising because it can be done" (if undertaken by competent men) "with very little extra trouble. It is merely a question of the page or column in which certain items are entered. It seems obvious that it is impossible to check the extravagances of any department unless the accounts of that particular department are kept separate from those of other departments."

14.—"The Complete Cost-Keeper"; by H. L. Arnold; published by The Engineering Magazine Co., 1900.

This work, with which almost every American engineer who has had to do with factory costs is familiar, is an outgrowth and development of Mr. Arnold's contributions to THE ENGINEERING MAGAZINE between the year 1895 and the date of publication of the work. These papers, which were contributed under the *nom de plume* of "Henry Roland," had attracted wide attention. The book presents various cost-keeping systems in actual use, varying in complexity. Every blank is given in full and has its actual sizes specified. A description is included of all mechanical aids to factory accounting, including time-clocks, recording clock stamps, computing machines, etc. Among the manufacturers whose systems are described, are Strieby & Foote, drop forgings, Newark, N. J.; The Hyatt Roller Bearing Co., Newark, N. J.; The DeLaval Separator Co., Poughkeepsie, N. Y.; Struthers, Wells & Co., Warren, Pa., steam and gas engines, boilers, etc.;

The National Switch & Signal Co., Easton, N. Y., and that of a prominent American electrical works, whose name is withheld, the last named being supplied by James N. Gunn.

15.—"Cost Accounts of an Engineer and Iron Founder"; by J. W. Best; a paper read before the Sheffield Chartered Accountants' Students' Society, December 12, 1900. London, Gee & Co.

Mr. Best's work is strictly confined to accounting. He believes that all cost accounts should be made to dovetail into the regular commercial accounting system. He begins with the final "Trading Account" into which have been entered the summarized results of the cost accounts. By working backwards he shows, step by step, how these accounts may be made to give just as much satisfaction as to balances as any of the ordinary double-entry accounts handled by a book keeper. Mr. Best illustrates each step by an actual form filled out, as used in foundry work.

16.—Cost Accounts; by C. A. Millener; The Hunter Rose Co., Ltd., Toronto, 1901.

Mr. Millener considers the subject of factory costs from the standpoint of the accountant rather than of the manager. Like most British writers on the subject, he works out a scheme which makes all the departmental and cost accounts part of the general double-entry book keeping of a corporation. His method of presentation is particularly clear, and the small folio of 60 pages is full of valuable suggestive matter, particularly as it deals with industries other than machine shops.

Mr. Millener recommends the monthly balancing of the final "Trading Account." He deprecates the practice of using estimated values of stock for inventory purposes, claiming that an inventory should give the exact actual cost of articles. If the goods would not realize their cost, the depreciation in value should be made good by a charge in "Trading" account and a credit to "Depreciation in Goods" account. In regard to what should be considered profits, he says "A true profit is only one that is actually realized by means of a sale." "An ample percentage on the volume of sales should be charged each year against Profit and Loss and credited to Bad Accounts, and a reserve gradually formed in excess of the usual yearly requirements, to cover all accounts finally abandoned as bad."

Sample accounts are given illustrating the accounting system as applied to a cement works, a flour mill, a sash and door factory, a clay works, and a coal-mining and iron-founding business.

17.—"A Bonus System of Rewarding Labor"; a paper by H. L.

Gantt; presented at the December, 1901 meeting of the American Society of Mechanical Engineers.

The paper is a description of a system introduced by the author into the machine-shop of the Bethlehem Steel Co. An instruction card is made out, showing in detail the best method (so far as knowledge and experience available can give it), of performing each of the elementary operations on any piece of work, specifiying the tools to be used, and setting the time needed for each of these operations as determined by experiments. The sum of these times is the total time needed to complete the piece of work. If the workman accomplishes all the work assigned in any one day within the total time limits specified, he is paid a definite fixed bonus, in addition to the day rate which he always gets. If he fails, he gets simply his day rate. As the time for each detail operation is specified on the instruction card, the workman can see continually whether he is going to earn his bonus or not. If he finds any operation which cannot be done in the time specified, he must at once report it to his foreman. If, on careful investigation by the man making out the card, the workman's statement is found to be correct, a new instruction card is made out, explaining the proper method of working, and allowing the proper time.

The foremen also receive, in addition to their day wages, compensation proportional to the number of their men who earn a bonus, and an extra compensation if all of their men earn bonuses.

> "As the instruction cards are made out by a skilful man with the records at hand, they invariably prescribe a better method for doing the work than the ordinary workman or foreman could devise on the spur of the moment. . . .
>
> "The system has many of the advantages of the differential piecework method, by which the compensation is quite large for the maximum amount of work obtainable. Since it is impossible for men to earn bonuses when their machines are out of order, an automatic punishment is provided for breakdowns. . . .
>
> "Considerable training is necessary to teach the men, who as a rule are ordinary laborers, to follow the instruction cards. Having once given them this training, however, the advantage of having a first-class machinist to do the thinking and to use for them the best results already obtained, produces an efficiency which would be absolutely impossible if the workmen were left to themselves."

Samples of the forms used are given, as filled out in actual use. The author states:

> "If we have a thorough knowledge of all the conditions, and are able to introduce piece work, it is undoubtedly to be preferred. But we must remember that aside from the great injustice of it, there is nothing so demoralizing as cutting piece rates."

The bonus system carries with it the advantage that if the time allowance is too easily reached, a limit is nevertheless set to any workman's daily gain, which can never be more than the fixed daily bonus.

18.—"The Cost of Production"; by Charles J. Watts; The Shaw-Walker Co., Muskegon, Michigan, 1902.

Mr. Watts' little work shows the application of the card system to all phases of cost-department accounting. In the method employed by him, the shop-department clerks do the direct entering of departmental details, separate card forms being used to cover departmental material, direct labor, and indirect labor. These cards are summarized by a central cost department. The card system is also used in localizing the general expense accounts, and in keeping a perpetual inventory. The style is concise and clear, and while the particular examples shown are from the agricultural-implement business, they are quite general in their application.

19.—"Cost-Keeper's Wage Schedule"; by G. Albert Lang; published by the author, St. Louis, Mo., 1902.

A table in book form, showing the earnings by 5-minute intervals, for all weekly wages between $2 and $25, by 25-cent intervals. The results are based on a 10-hour day. The book is indexed by tabs for the weekly wage.

20.—"Shop Management"; by Fred Taylor; a paper presented at the June, 1903, meeting of the American Society of Mechanical Engineers.

This exhaustive paper, which covers 150 pages of the Society's Transactions, is a record of some twenty years of genuine research work by the author. The compiler of this bibliography emphatically agrees with Mr. Henry R. Towne in his characterization of this paper as the most valuable contribution to this subject which has yet been made. As stated by Mr. Towne, it includes so complete a review as to constitute almost a history. It is clear-cut and comprehensive, written in a characteristic, vigorous, clear style.

Mr. Taylor brings out again, and in greater detail than in his former paper of 1895, the importance of scientific time study as the foundation of the best management. In addition to the more detailed description of scientific rate fixing, the other new features not brought out in his previous paper referred to are the use of the "Instruction Card" to accompany any system of compensation, whether it be Mr. Gantt's bonus, Mr. Taylor's differential piece rate, the premium method, or ordinary piece rate; also the system of functional foremanship.

Functional management consists in so dividing the work of man-

agement that each man, from the assistant superintendent down, shall have as few functions as possible to perform. If practicable, the work of each man in the management should be confined to the performance of a single leading function. As examples of this functional management, there are suggested, in the factory office, the man in charge of order of work or routing department, the one in charge of instruction-card department, the time and cost clerk, and the shop disciplinarian, these four divisions making up what Mr. Taylor calls the "planning department." In the shop itself the functional foremanships are those of "gang boss," who has charge of the preparation of all work up to the time the piece is set in the machine, including the selection and providing of jigs, templets, drawings, etc.; the "speed boss," who must see that the proper cutting tools are used, that the cuts are started right, and that the best speeds and feeds are employed; the inspector, who is responsible for the quality of the work; and the "repair boss," who sees that each machine is kept clean by its operator and free from rust and scratches, and that it is oiled and otherwise properly treated.

While the complete scheme as outlined by Mr. Taylor is applicable in all its details only to large works, the principles emphasized are capable of application in moderate-sized shops.

21.—"The Factory Manager and Accountant"; by Horace L. Arnold; 1903. The Engineering Magazine Co., New York. Mr. Arnold's second work, like his first, is a presentation of working systems as employed by prominent American manufacturing corporations. Mr. Arnold does not spend any time in theorizing or arguing. He presents the system to the reader, who can judge for himself whether the conditions in his case are similar to one or the other of the examples given. To use the author's own words:

> "As the able manager looks over his own particular industrial kingdom, small or large, in the new light of defining and recording inevitabilities, and considers the means by which he shall place and direct his assistants, and record their acts, and shall also place and record the movements of every piece and thing inside the factory walls, he is appalled by the endless series of record-forms needed, and the endless labor of writing the records. Hence the practicable solution of the problem is to be found most surely through studying exactly what others have done with success."

Among the corporations whose systems are described, are the Link-Belt Engineering Co., the Bigelow Co., New Haven, Conn., the C. B. Cottrell & Sons Co., Westerly, R. I., the Potter & Johnston Machine Co., Pawtucket, R. I., The Wells Bros. Co., Greenfield, Mass. and the C. W. Hunt Co., West New Brighton, N. Y.

22.—"Manufacturers' Accounts"; by W. C. Eddis and W. B. Tindall; published by the authors, Toronto, 1904.

The general scheme of accounting is identical with that used by Mr. Best in his "Cost Accounts of an Engineer and Iron Founder." The general results of the business are shown in a "Trading Account" to be balanced at frequent intervals. Going backward from this the component accounts and entries are illustrated, the idea being to apply the ordinary methods of commercial double-entry accounting books to all phases of cost accounting. The particularly distinctive feature of the work is that designated at Part II, which gives specific examples of the system as applied, first to an engine and boiler manufactory, second, to a candy-manufacturing establishment, and third, to a lumber establishment. A third part is composed of forms of general commercial books to be used in connection with the cost-accounting methods advocated.

23.—Workshop Costs for Engineers and Manufacturers; by Sinclair Pearn and Frank Pearn; 21s, net; size 18 by 10, 34 pages and 42 full-size rulings and specimen entries; 1904.

Describes the system worked out by the writers as managing directors of the well-known Manchester Pumping Machinery works, with special reference to costs of machines of which the parts are standardized. A very important book, owing to the practical nature of the information and the excellent working examples and forms given. No attempt is made to deal with establishment charges, but as a prime-cost system and organization the method described should be studied by all interested in factory accounting.

INDEX TO THE PERIODICAL LITERATURE OF INDUSTRIAL ENGINEERING.

Editorially Compiled.

PRIOR to the establishment of The Engineering Index, which now forms a department in every issue of THE ENGINEERING MAGAZINE, no effective attempt had been made to catalogue the contents of the technical press. There was no method, except the impossible one of exhaustive reading, by which the specialist could learn what was being published in his own particular subject, to say nothing of keeping himself informed as to the general progress of cognate branches. Twenty-one years ago, the late Prof. J. B. Johnson began the systematic indexing of current engineering journals, with the additional characteristic idea of embodying in each index reference a concise descriptive note, sufficient to define, to the consultant of the work, the scope and character of each article, and thus to save him the labor of looking up such as were not useful to his purpose.

As taken up and expanded by this Magazine, the work has grown to a range and to dimensions far exceeding any contemplated by its founder. As it appears monthly in THE ENGINEERING MAGAZINE, it is a classified summary of all the current technical literature—American, English, or Continental—interesting to engineers. As it is republished from time to time in volume form, it is an exhaustive reference index to the technical press of the period it covers.

The following special index to articles on all phases of industrial engineering, like the preceding bibliography of the more permanent contributions to the subject, is a pioneer work in the selection and compilation of the entire body of its literature. It is based on Volumes I, II, and III of THE ENGINEERING INDEX and on the monthly index in THE ENGINEERING MAGAZINE since the date of the last volume (1900). The arrangement under the classified headings is chronological, with the idea of making this index a display of the historical development of the science of works management. It is of interest to note that hardly a single reference was found in Volume I, and few in Volume II. From that time on the number increases in rapid progression. Those who are closely interested in the subject may find in this index a fairly complete reference list up to the present time, which may be kept up to date by the use of THE ENGINEERING INDEX as it appears monthly in this Magazine.—THE EDITORS.

AN INDEX TO THE LITERATURE OF INDUSTRIAL ENGINEERING.

APPRENTICESHIP.

*Education for the Workshop. Frederic A. C. Perrine. A discussion of the best means of giving young mechanics a higher training, particularly in night schools. 3000 w. The Engineering Magazine—May, 1892.

Presidential Address of Mr. Archibald Denny. Delivered before the Inst. of Junior Engineers, upon the apprentice system, and the handling of young men in the drawing office, the workshop and in business positions. 5500 w. Engineer, London—Nov. 15, 1895.

Apprenticeship. Editorial on an article in the *London Technical Education Gazette* which was a summary of results of a systematic inquiry into the state of apprenticeship in the various trades of London, and views of various employers regarding the possibility of developing the system in the future. The article deals only with the building trades. 2800 w. Builder—Nov. 16, 1895.

The Apprenticeship System under Modern Conditions. System employed in the shops of the Brown & Sharpe Company. 800 w. Scientific American—July 4, 1896.

The Training of Apprentices. The system in use in the French railway workshops, where the apprentice is educated in theory, simultaneously with his manual training. 1100 w. Engineering—July 17, 1896.

Status of Apprenticeship in the Trades Concerned in the Production of Machinery. Letters from 116 of the most prominent machinery building establishments and important railway systems of the country, stating their practice and views regarding apprenticeship. 24,000 w. American Machinist—Dec. 24, 1896.

The Improvement of the Apprenticeship System as a School for Mechanics. Discussion of the relation of employer and apprentice and the means of making this system of value, with reasons. 2800 w. Engineering News—March 4, 1897.

An Apprenticeship System in College Shops. O. P. Hood. Read at the Columbus meeting of the Society for the Promotion of Engineering Education. Explains the opinions that led to a trial of an apprentice system, the results, and the writer's belief in its usefulness. 1600 w. American Machinist—Aug. 24, 1899.

Mechanics, Their Relation to Each Other and to Mechanical Industries—Trade Schools. John E. Sweet. Excerpts from an address delivered at Rochester, N. Y., on the apprenticeship feature of the mechanical industries and trade schools. 3700 w. American Machinist—Sept. 7, 1899.

Modern Apprenticeship Conditions. John E. Sweet. From an address before the manufacturers and mechanics of Rochester, N. Y. Considers the training of the schools and of the shops, and the duties of employers and employees. 4500 w. Iron Trade Review—Jan. 18, 1900.

The Problem of the Molder. John G. Sadlier. The slow advancement in foundry practice, and the importance of selecting the right apprentices and educating them. 1800 w. Journal American Foundrymen's Ass'n—June, 1901.

A Systemate Plan of Apprenticeship. Describes the plan at the Baldwin Locomotive Works, with editorial comment. 2000 w. American Engineer & Railroad Journal—Oct., 1901.

The Technical Education of Railway Apprentices in France. A description of the educational system afforded by apprenticeship classes of the Chemins de Fer de l'Est. 4800 w. Engineer, London—Jan. 24, 1902.

What Can Our Schools Do for Foundry Apprentices? P. Kreuzpointner. Discusses school training and what should be demanded of apprentices. 4800 w. Journal American Foundrymen's Association—Feb., 1902.

*The Present Industrial Importance of Technical Education. Sir Philip Magnus. A review of the relation of technical education to commercial supremacy, with reference to the foresight of Germany as compared with Great Britain. 4000 w. The Engineering Magazine—Nov., 1902.

Apprenticeship in Engineering Training. John Dewar Cormack. Read before the Engng. Con. of the Inst. of Civ. Engrs. The discussion is confined to the training of youths destined for responsible positions, as employers, manufacturers, consulting engineers, etc. Also general discussion 8000 w. Engineering—June 26, 1903.

The Apprenticeship System at Brown & Sharpe's. William A. Viall. Read at meeting of Nat. Mach. Tool Bldrs. Assn. 1800 w. Iron Age—July 2, 1903.

College or Apprenticeship. Louis H. Ransome. A consideration of the two systems of training, with a view to seeing in what direction improvements should be sought. 2000 w. Engineer, London—Aug. 21, 1903.

Apprenticeship in Engineering Training. John Dewar Cormack. A discussion of the best training and the conditions that should be fulfilled. 1800 w. Railroad Gazette—Sept. 11, 1903.

Engineering Apprentices. D. B. Morison. Outlines a scheme for the advancement of apprentices to be given a trial at the Hartlepool Engine Works. Also editorial. 2400 w. Engineering—Sept. 25, 1903.

Apprenticeship. Robert Patterson. A paper read before the Canadian Railway Club, describing the system of training apprentices at the shops of the Grand Trunk Railway. 2500 w. Railroad Gazette—Oct. 2, 1903.

The Apprenticeship Question. John E. Sweet. Read before the Mutual Trades Assn. of Syracuse, N. Y. Remarks on the changed conditions and the necessity of providing proper instruction for American boys who wish to become mechanics, suggesting ways. 2800 w. American Machinist—Oct. 22, 1903.

*The Training of Apprentices in Engineering Works. C. E. Downton. A description of the system and methods of training apprentices in the works of the Westinghouse Electric and Manufacturing Co. 3500 w. The Engineering Magazine—Dec., 1903.

The Money Value of Technical Training. James M. Dodge. President's address at meeting of the Am. Soc. of Mech. Engrs. Also editorial. 5000 w. Engineering Record—Dec. 5, 1903.

*An Example of the Modern Development of the Apprenticeship System. L. D. Burlingame. Describing the sysytem in successful operation in the shops of the Brown & Sharpe Mfg. Co., at Providence. 3500 w. The Engineering Magazine—Jan., 1904.

*The Mechanic of the Future and His Training. E. P. Watson. A comparison of the modern manual-training methods with the older apprenticeship system, showing the necessity for experience in the commercial shop. 4000 w. The Engineering Magazine—Feb., 1904.

The Technical Graduate and the Machinery Department of Railroads. W. F. M. Goss. Outlines the development of the technical graduate, his training, etc., and considers some of the defects in the administration of special apprenticeship, and the remedy. General discussion. 12,500 w. Proc Western Railway Club—March 15, 1904.

*Apprenticeship Systems of the Allis-Chalmers Company. P. W. Gates. A practical system, ad-

Throughout this index, the asterisk (*) prefixed to the title of an article indicates that it appeared originally in THE ENGINEERING MAGAZINE.

justable to widely diversified conditions. 2000 w. The Engineering Magazine—April, 1904.

*What Manchester is Doing for Engineering Apprentices. F. Brocklehurst. An account of the great electrical and mechanical trade school at Manchester. 3000 w. The Engineering Magazine—May, 1904.

*The System of Apprenticeship at the Baldwin Locomotive Works. S. M. Vauclain. Description, with illustrations and diagrams, of the three classes of apprentices, and other features of a system which has long been in use with most successful and fortunate results. 2000 w. The Engineering Magazine—June, 1904.

COST-KEEPING.

Cost in Manufactures. Henry Metcalf. A lecture at Cornell University on methods of obtaining costs. Scientific American Sup—Aug. 6, 1887.

Methods of Ascertaining the Cost of Manufactures. Prof. C. H. Benjamin. Paper before the Civil Engineers' Club of Cleveland. Abstract, with record forms, etc. Journal Ass'n of Engineering Societies—March, 1891.

Some Uses of Cross-Section Paper in the Machine Shop. William O. Webber. Its use in keeping the run of shop expenses and estimating cost of jobs. 1100 w. American Machinist—Nov. 21, 1895.

The Use of Graphical Methods in Keeping the Accounts of Railway Mechanical Departments. An advocacy of the system, with illustration taken from a western road. 900 w. American Engineer & Railroad Journal—June, 1896.

Cost-Keeping—Some Large Air Hoists—A Right-Angle Coupling—A Rack Cutter—The Centers of Arbors. S. T. Freeland. Brief consideration of subjects named. 2600 w. American Machinist—Nov. 12, 1896.

A Method of Determining Selling Price. H. M. Lane. Tells how conditions determining the yearly balance sheet may be shown at the end of each month or week. 1700 w. Trans. American Society of Mechanical Engineers—Dec., 1896.

Valuation of Manufactures. Oberlin Smith. Discussion of appraisers' work; advocates valuations too low rather than too high. 3300 w. American Machinist—Dec. 17, 1896.

*Mine Accounts. J. Parke Channing. Analyzing the expenses of mine operation and suggesting a method of recording them. 3700 w. The Engineering Magazine—Sept., 1897.

*Cost-Keeping Methods in Machine Shop and Foundry. Henry Roland (H. L. Arnold). A series of four articles. The Engineering Magazine—Oct., Nov. and Dec., 1897, and Jan., 1898.

No. 1. Elements, and influence of wage systems. 3700 w.

No. 2. Details of several large shops compared, especially piece-work systems. 6000 w.

No. 3. Methods of leading shops for checking piece production. 4000 w.

No. 4. General expense and selling price. 3500 w.

An Electrical Time-Recording System. A method of automatically operating a number of subsidiary clocks from a master timepiece. Ill. 1000 w. Practical Engineer—Oct. 8, 1897.

Diagram Accounts for Engineering Works. John Jameson. Paper before the Institution of Mechanical Engineers. 2800 w. Engineering—Nov. 12, 1897.

Time Saving and Its Relation to Profits. Henry Hess. Analysis of methods for reducing costs, with examples and diagrams. 4200 w. American Machinist—Dec. 16, 1897.

Method of Keeping Weekly Shop Costs. W. N. Moore. A method which has proved effective after several years' experience. 1300 w. Railway & Engineering Review—Dec. 18, 1897.

The Bundy Time Recorder. Illustrated detailed description. 1300 w. Engineer, London—March 11, 1898.

Cost-Keeping and Accounting. W. S. Rogers. Paper and discussion before the N. Y. Railroad Club. 7500 w. N. Y. Railroad Club—Sept. 15, 1898.

The Card-Index System of Cost-Keeping. Illustrated description of methods used by the Bullard Machine Tool Co., of Bridgeport, Conn. 2500 w. American Machinist—Sept. 15, 1898.

*Effective Systems of Finding and Keeping Shop Costs. Henry Roland (H. L. Arnold). A series of eight articles. The Engineering Magazine—April-Nov., 1898.

No. 1. An exposition of the "job-ticket" system. 3500 w.

No. 2. The collective job-ticket system as applied in a drop-forging works. 3500 w.

No. 3. Methods in use at machine tool works of Bement, Miles & Co., Philadelphia. 3000 w.

No. 4. Newton Machine Tool Works, Philadelphia. 3500 w.

No. 5. Hyatt Roller Bearing Co. 4000 w.

No. 6. Sprague Electric Co. 4500 w.

No. 7. Minutely-divided accounts of a signal-manufacturing company. 5000 w.

No. 8. Methods of determining and apportioning the expense account, including the relations of productive labor to general expense. 8500 w.

*A Simple and Effective System of Shop Cost-Keeping. H. M. Norris. Gauging the cost of work in process of manufacture, with many blank forms. 4500 w. The Enginering Magazine—Dec., 1898.

A Colliery Cost Sheet. G. Johnson. Illustrations of bank and underground pay-bills. 1100 w. Colliery Guardian—March 3, 1899.

Shop and General Establishment Charges in Engineering Works and Their Relation to Costs and Estimates. Wm. Edward Cowens. Paper before the Northeast Coast Inst. of Engineers and Shipbuilders, written from the works manager's standpoint. 2800 w. Ind & Iron—May 5, 1899.

The Balance Sheet of a Mining and Manufacturing Company. George Johnson. Describes in some detail the various assets and liabilities. Serial. 1st part. 3800 w. Iron & Coal Trades Review—Sept. 1, 1899.

An Automatic Cost Distributing and Accounting Plan. W. S. Rogers. Describes plan as worked out and applied. 3000 w. Iron & Coal Trades Review—Nov. 10, 1899.

Uniform Accounting for Gas and Electric Lighting Companies. James Blake Cahoon. Abstract of paper at Chicago meeting of Nat'l Electric Light Assn., and editorial on "Uniform Accounting a Prerequisite to National Municipal Statistics." 3000 w. Engineering News—June 14, 1900.

Cost-Keeping at the Chicago Works of Fraser & Chalmers. Describes a system that has been in satisfactory operation for four years. Serial. 1st part. 2200 w. American Machinist—Nov. 1, 1900.

*The Expense Account of the Machine Shop. Horace L. Arnold. A discussion of an important element in cost-keeping, showing the true method of treating indirect factory expenditures. 3500 w. The Engineering Magazine—Dec., 1900.

*Cost-Keeping: A Subject of Fundamental Importance. J. N. Gunn. A discussion of the fundamental principles essential to the establishment of a satisfactory system. 3000 w. The Engineering Magazine—Jan.,1901.

The Principles of Cost Accounting. F. A. Halsey. Lecture before the mechanical engineering students of Cornell Univ. Discusses the objects of cost accounting, the principles involved, methods, etc. 8000 w. Sibley Journal of Engineering—April, 1901. Also in American Machinist—June 20 and 27, 1901.

Mine Account Keeping and the Monthly Statement of Costs, as Adapted to the Business of Metalliferous Mining. Charles V. Jenkins. Describes a thorough system. 10300 w. Mines & Minerals—Aug., 1901.

*The Proper Distribution of the Factory Expense Burden. A. Hamilton Church. A series of six papers. The Engineering Magazine—July to Dec., 1901.

No. 1. The interlocking of general expense with price costs. 3500 w.

No. 2. Camparison of the various methods of apportioning expense to work, depending on the character of the work. 4000 w.

No. 3. The scientific machine rate and the supplementary rate, with development of an accurate system. 3300 w.

No. 4. The classification and dissection of shop charges. 4500 w.

No. 5. Factory and mass production, and the new machine rate. 3500 w.

No. 6. The proper apportionment of office and selling expense, and general summary of the whole series of papers. 4000 w.

*Aids in Taking the Machine-Shop Inventory. Hugo Diemer. Discussing a simple method of employing the card index and showing its advantages for inventory purposes. 2500 w. The Engineering Magazine—Feb., 1902.

Analyzing Cost of Machinery Making. Oberlin Smith. 2800 w. Iron Trade Review—April 3, 1902.

Workshop Records in Cards and Files. George Parker. Read before the Northeast Coast Inst. of Engineers & Shipbuilders (Great Britain). Describes applications of cards for various purposes, and gives the origin of the system. 7700 w. Iron Trade Review—May 1, 1902.

Cost-Keeping and Wage System of the Stilwell-Bierce & Smith-Vaile Co. Descriptive articles outlining the system of the purchasing department. 2300 w. Iron Trade Review—June 5, 1902.

Co-Operative and Mechanical Aids to Workshop Cost-Keeping. R. P. Link. Read before the Inst. in Sunderland. Calls attention to the method of utilizing automatic machines to control the keeping of costs in shops. Also discussion. 4800 w. Trans. of N. E. Coast Inst. of Engineers & Shipbuilders—July, 1902. Also in Mechanical Engineer of April 26, 1902.

Workshop Records. A Review and Comparison of Existing Methods, with Special Reference to the Use of Cards and Files Instead of Books. George Parker. Read before the meeting in South Shields. Also discussion and 2 plates. 13400 w. Trans. of N. E. Coast Inst. of Engineers & Shipbuilders—July, 1902.

Shop-Record System of the Pearson Machine Company. Describes methods in use in a shop which manufactures turret lathes, screw machines, forming and drilling machines, and horizontal boring machinery. 1300 w. Iron Trade Review—July 3, 1902.

A New Factory Cost-Accounting System. Wilfred Bancroft. Describes a method devised to furnish the fullest possible information about every operation, on every piece, in a machine containing some 1,500 pieces. 3800 w. American Machinist—July 24, 1902.

The Electrical Tabulating Machine Applied to Cost Accounting. An illustrated article explaining the method of utilizing this machine in manufacturing establishments. 2000 w. American Machinist—July 31, 1902.

Cataloging Small Machine Parts. L. P. Alford. Describes a system used in cataloging and arranging the data regarding the small parts of about 150 machines. 2000 w. American Machinist—Sept. 25, 1902.

*Cost-Finding Methods for Moderate-Sized Shops. H. L. Arnold. The methods of the Bigelow Company, of New Haven, Conn., employing about 200 men in the manufacture of steam boilers. 3000 w. The Engineering Magazine—Dec., 1902.

*Cost-Finding Methods for Moderate-Sized Shops. A Successful Example Under the Premium Wage System. Hugo Diemer. A description of the methods of the Cincinnati Milling Machine Co. 2500 w The Engineering Magazine—Jan., 1903.

The "Duca" Card System. Robert Grimshaw. Gives card forms used by a German machinery manufacturer for keeping an account of office and shop items, with explanatory notes. 1900 w. Iron Trade Review—Jan. 1, 1903.

*Cost-Finding Methods for Moderate-Sized Shops. H. L. Arnold. A description of the system in practical use at the Cottrell printing-press works, Westerly, R. I. 3500 w. The Engineering Magazine—Feb., 1903.

*Cost-Finding Methods for Moderate-Sized Shops. William Magrutor. A description of the system of the Southern Engine and Boiler Works, employing about 300 men on engines, boilers, and saw-mill machinery. 2500 w. The Engineering Magazine—March, 1903.

Comparative Statements. Henry W. Brooks, Jr. On the importance of intelligent accounting, and the value of comparative statements showing the results of any change in policy or methods. Refers chiefly to street railway work. 2500 w. Street Railway Review—March 20, 1903.

*Cost-Finding Methods for Moderate-Sized Shops. Kenneth Falconer. A general account of the system used by the Canadian Company, engaged in the manufacture of type-composing machines; giving details and forms used. 2500 w. The Engineering Magazine—April, 1903.

*The General Principles of Mine Accounting. E. Jacobs. A comparison of the engineering methods of mining with the corresponding business principles applicable to the recording and accounting work of the commercial side. 3000 w. The Engineering Magazine—April, 1903.

*A Practical System of Mine Accounting. E. Jacobs. The methods of the Le Roi, B. C., Mines, with reproduction of all the forms, blanks, book rulings, and record sheets. 3000 w. The Engineering Magazine—May, 1903.

A Work-in-Progress Record. Horace L. Arnold. Describes two forms in use in the Cottrell works for historical records of events. 2200 w. American Machinist—April 23, 1903.

A Work-in-Progress Record. Kenneth Falconer. Gives forms used by the writer to furnish a history of each productive order. 1000 w. American Machinist—May 28, 1903.

A Card Purchasing System. W. R. Gaither. Purchasing system for street and electric railways. 600 w. Street Railway Journal—May 30, 1903.

A Graphical Daily Balance in Manufacture. H. L. Gantt. A continuation of a former paper by the author calling particular attention to the method of setting the task and the method of operating the system by which an exact record is kept. 3800 w. Trans. American Society of Mechanical Engineers—June, 1903.

Methods of Calculation in Machine Construction (Ueber Kalkulations-Methoden in Maschinenbau). Sigm. Stephan Récsei. A discussion of the fundamental methods of computing factory costs in machine building, deriving formulas, and comparing methods of wages, depreciation, inventory, etc. Two articles. 8000 w. Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines—Aug. 7 and 14, 1903.

A Shop Cost System. Lin. Wood. Describes a system for finding and keeping the shop cost of work produced, which may be applied to almost any shop. 1400 w. American Machinist—Aug. 27, 1903.

Pratt's Record Scroll. Horace L. Arnold. Illustrates and describes this scroll, and states its advantages. 1400 w. American Machinist—Sept. 17, 1903.

Mine Accounting. Walter M. Jeffery. Read before the Lake Superior Mining Inst. Shows the importance of uniform systems for all mines under same ownership. 3400 w. Mines & Minerals—Oct., 1903.

A Card System for Mine Supply Accounts. F. W. Denton. Read before the Lake Superior Mining Inst. Describes a method by which the amount and value of supplies on hand can always be known. 1800 w. Mines & Minerals—Oct., 1903.

*Manufacturing: Capital, Costs, Profits and Dividends. Henry Hess. Developing an improved graphical method of analyzing and interpreting cost accounts and works records. An important paper. 3500 w. The Engineering Magazine—Dec., 1903.

The Preparation of Estimates. Analysis of the reasons for the great disparity in estimates for the same work, and study of the conditions which will ensure more uniformity. Serial. 1st part. 2800 w. Engineer, London—Jan. 1, 1904.

The Cost-Keeping System of Ludwig Loewe & Co., Berlin (Die Berechnung der Lohn Kosten in der Fabrik von Ludwig Loewe & Co. A.-G. in Berlin). M. Chr. Elsner. Giving reproductions of the forms and the methods of using them for obtaining the flat factory cost of manufacture. 2000 w. Zeitschrift des Vereines Deutscher Ingenieure—Jan. 9, 1904.

Two Card Systems for the Shop. H. C. Hammack. A card-index method of keeping employee's records, and a "follow-up" system for manufacturers and jobbers. 2500 w. Iron Trade Review—Feb. 4, 1904.

A Card-Index System for Obtaining the Cost and Distribution of the Non-Productive Labor. George P. Pearce. 2400 w. American Machinist—Feb. 11, 1904.

Card Systems and Diagrams—Keeping Track of Stock-Factory Management. J. S. V. Bickford. 2200 w. American Machinist—April 14, 1904.

*Cost-Keeping and Shop Statistics for a Repair Shop. A. W. Thompson. Illustrated description of a practical system in the repair shops of the Amoskeag and Manchester (N. H.) textile mills. 3000 w. The Engineering Magazine—May, 1904.

Depreciation.

*The Depreciation of Plant and Its Relation to General Expense. H. M. Norris. The practice of a number of metal-working establishments in cost-keeping, with reference to charges for depreciation of machines. 4300 w. The Engineering Magazine—Feb., 1899.

*Machine-Tool Depreciation as an Element of Manufacturing Cost. H. M. Norris. Discussing the practice of various establishments, and suggesting a solution of the problem from the author's experience, with forms and tables. 4500 w. The Engineering Magazine—March, 1899.

*Depreciation as an Element of Machine-Shop Cost-Keeping. H. M. Norris. The relation of depreciation to general expense, showing the various methods adopted in writing off plant and the use of cost diagrams. 4500 w. The Engineering Magazine—April, 1899.

Sinking-Fund Charges. W. H. Booth. A discussion of the best method of dealing with depreciation of a plant and buildings, and related matters. 3300 w. Tramway & Railway World—April 9, 1903.

Foundry.

Itemized Cost of Castings. Robert Grimshaw. A system of cost accounting for foundry work as carried out in a leading manufacturing establishment. 1400 w. Machinery—March, 1896.

Foundry Costs. R. C. Cunningham. Calls attention to points affecting the economy, and offers suggestions. 1800 w. Jour. American Foundrymen's Ass'n—June, 1901.

Foundry Accounting. J. G. Stewart. Examines in detail methods of keeping records, and remarks on the importance of knowing accurately the cost of work, etc. 5000 w. Jour. American Foundrymen's Ass'n—June, 1902.

Foundry Costs. R. C. Cunningham. Suggestions for improving the output and diminishing the costs, by supplying needed tools, careful oversight, etc. 1700 w. Jour. American Foundrymen's Ass'n—June, 1902.

*The Recording and Interpreting of Foundry Costs. Percy Longmuir. A discussion of practical methods from the point of view of the manager, with numerous tables and diagrams. 2000 w. The Engineering Magazine—Sept., 1902.

The Cost-Keeping Systems of an Ohio Jobbing Foundry. Outlines the system used in a foundry employing a large force of workmen on a great variety of work. 1200 w. Iron Trade Review—Sept. 4, 1902.

Cost-Keeping in Foundries. Edward Kirk. Arguing that nothing of value is gained, and the labor really adds to the cost of castings. 2800 w. Foundry—Feb., 1903.

Foundry Accounting and Methods of Estimating Cost of Castings. O. C. Barrows. Read at meeting of the New England Foundrymen's Ass'n. Describes a method that has proved satisfactory. 3500 w. Iron Trade Review—April 16, 1903.

An Order System for Foundries. J. Byron Henry. Methods in shops with a large output that make a specialty of jobbing orders. 1200 w. Foundry—May, 1903.

Foundry Costs: Their Analysis and Reduction. Henry Hess. Outlines a successful method. Discussion. 4000 w. Proc. Engineers' Club of Philadelphia—Jan., 1904.

Patterns.

Pattern Shop Cost. A. Sorge, Jr. A method which gives classified costs in a readily comparable form; restricted in this article to wood patterns, but can easily be extended to metal patterns. 6000 w. Iron Age—June 18, 1896.

Numbering and Storing Patterns. S. A. Worcester. The arrangement of shelves and other features. 1000 w. American Machinist—April 30, 1903.

Pattern Costs. R. W. Mac Dowell. Explains a system of keeping accurate costs of patterns, giving forms used. 1500 w. Iron Trade Review—May 5, 1904.

DRAWING ROOM.

A System of Drawing-Room Records. The outgrowth of a process of trial covering an extended period. 1500 w. Machinery—Dec., 1896.

The Decimal Index in the Drafting Room. H. W. Alden. Describes a system providing a simple and ready reference for drawing, and a logical pattern number which indicates the use for which the pattern was intended. 2000 w. American Machinist—Feb. 4, 1897.

Office Furniture, Engineering Department, Metropolitan Water Works. Giving details of drawing cases, drawing tables, blue print apparatus, etc., as used by the Metropolitan Water Board, Boston. 3500 w. Engineering Record—Sept. 17, 1898.

The Drawing Office. C. E. Hodgkin. Read before the Falcon Works Engng. Soc. On the importance of good delineation, the functions of draftsmen, etc. Serial. 1st part. 2500 w. Practical Engineer—Sept. 1, 1899.

Office System for Drawings. Henry R. Towne. Trans. American Society of Mechanical Engineers—Vol. V, 1884. Also in Mechanics—June and July, 1884.

*The Modern Mechanical Drawing Room. Prof. C. W. MacCord. A discussion of proper arrangement, furnishing and system. 3500 w. The Engineering Magazine, Sept., 1894.

Drawing Office Method. J. R. S. in "New York Railroad Men." An outline of methods used in practice respecting indexing, drawing, scales, tracings, numbering drawings, etc. 600 w. Railroad Car Journal—Nov., 1895.

The Gates Iron Works Drawing Room. John Randol (H. L. Arnold). Illustrated detailed description, with plan of room, etc. 2200 w. American Machinist—Jan. 16, 1896.

Hints for the Drafting Room. W. S. Huyette. Practical suggestions, particularly with reference to keeping records of constructive changes. 1200 w. Machinery—March, 1896.

System in the Drafting Room. James C. Hemphill. Illustrated description of a system in actual use for arranging, classifying and indexing miscellaneous drawings for easy reference. 700 w. Machinery—Nov., 1896.

A Model Drafting Room. Illustrates and describes a convenient arrangement with novel features. 1500 w. Machinery, N. Y.—Jan., 1900.

The New Drawing Office of the Schenectady Locomotive Works. Illustrated description of an office with the best facilities. 1500 w. American Machinist—Jan. 18, 1900.

A Modern Drafting Room. Illustrated description of a room in which the heating, lighting and ventilation are special features. 1200 w. Machinery, N. Y.—Feb., 1900.

The New Drafting Room of the Brown & Sharpe Manufacturing Company. L. D. Burlingame. Illustrated detailed description of a finely equipped room. 2000 w. American Machinist—March 8, 1900.

Drafting Department, Union Iron Works. Illustrated description of the special drafting building, furniture and methods of management. 3000 w. Engineering Record—March 10, 1900.

Drawing-Office System of the Bullock Electric Manufacturing Company. W. H. Warren. Describes some features of the room and its furnishings, and the system used. 3800 w. American Machinist—June 7, 1900.

Rules for a Drawing Office. A. W. Robinson. 1500 w. Trans. American Society of Mechanical Engineers, No. 897—May, 1901.

Drafting-Room and Shop Systems. Frederick O. Ball. A description of systems, with illustrations. 4000 w. Trans. American Society of Mechanical Engineers, No. 909—May, 1901.

An Outline of the Drawing-Office System of the General Electric Company. S. L. G. Knox. Describes a system found satisfactory in an establishment employing over three hundred draftsmen and having a total of over twelve thousand men. Ill. 3000 w. American Machinist—July 25, 1901.

Indexing Railway Maps and Drawings. R. C. Vial. Describes a system which has proved satisfactory in the drafting-room of the Chicago & Western Indiana R. R., based on the decimal system. 5,000 w. Engineering News—Sept. 5, 1901.

A Decimal System for Numbering Working Drawings. Henry L. Hutson. Describes a system similar to the Dewey Decimal System. Also editorial. 2000 w. American Machinist—Dec. 26, 1901.

Drawing Room; Chief Engineer's Office; Pittsburg & Lake Erie R. R., Pittsburg, Pa. R. P. Forsberg. Illustrated description of the room, tables, card-index system, drawings, filing cases, blueprint room, etc. 3200 w. Engineering News—Jan. 2, 1902.

Average Drawing-Room Practice. C. E. Cooledge. Gives questions sent out by Prof. Barr, of Sibley College, Cornell, and the replies received, with a view of forming an average system. 1600 w. American Machinist—June 19, 1902.

Standard Drawings. Warren E. Willis. Gives suggestions for drafting-room standards. 1600 w. Machinery, N. Y.—Aug., 1902.

*The Relations of the Draftsman to the Workshop. W. H. Booth. A discussion of this fundamental question of efficient shop organization, including the preparation and execution of designs for engineering work. 3000 w. The Engineering Magazine—Oct., 1902.

The Lodge and Shipley Drawing Room. Illustrated description of a well arranged office having features of interest. 1500 w. Machinery, N. Y.—Oct., 1902.

Numbering and Filing Drawings. S. A. Worcester. An outline of a system recommended, with a brief comparison with other methods. 1800 w. American Machinist—April 16, 1903.

Drawing-Office Equipment. John McGeorge. Discusses light, natural and artificial, space allotted to each man, types of drafting boards, sanitary arrangements, blue print facilities, etc. 3000 w. Ill. Trans. American Society of Mechanical Engineers—June, 1903.

Some Features of the Drawing-Office System of the C. W. Hunt Co. Description, with illustrations. 1600 w. American Machinist—July 9, 1903.

Mechanical Drawing and Its Relation to Practical Shop Work. L. D. Burlingame. An address before the Eastern Manual Training Ass'n. Considers the drafting department as the interpreter to the shop, of the shop, and for the shop. 4000 w. American Machinist—July 30, 1903.

A Filing and Indexing System for Drawings. E. C. de Wolfe. Describes the system used by the Dodge Mfg. Co., at Mishawaka, Ind. Serial. 1st part. 3000 w. American Machinist—Nov. 12, 1903.

A Modern Drawing Office. Joseph Horner. Considers the requirements, giving hints on the filing of drawings and plans, and discusses the equipment of the pattern shop and allied questions. 2400 w. Page's Mag—Dec., 1903.

Systematizing Drawing-Office Standards. The first of a series of articles intended to illustrate a method of organized work, especially in that connected with stationary steam-engine plants. Serial. 1st part. 1200 w. Practical Engineer—Dec. 18, 1903.

The Group Drawing-Office System. Walter Ferris. Describes this system as used by the Bucyrus Co. 3400 w. American Machinist—Jan. 28, 1904.

WAGE SYSTEMS.

Wages and Hours of Labor in Great Britain and Ireland. Synopsis of report published by the Labor Dep't of the British Board of Trade. Tabulated statistics, etc. 2700 w. Bulletin Dept. of Labor—Jan., 1896.

Continental and English Wages. A comparison of wages in steel works. 700 w. Iron & Coal Trades Review—Feb. 7, 1896.

The Labor Question in an English Foundry. R. A. Hadfield. Discussion of day labor vs. piece work and other matters. 2200 w. American Machinist—March 19, 1896.

The Statistics of Wages and the Cost of Living. The seventh and closing lecture in the special course on Social and Industrial Statistics, by Carroll D. Wright, U. S. Com'r of Labor, at the School of Social Economics, New York. Abstract by J. B. Walker. 1000 w. Scientific American Sup —March 28, 1896.

Labor's Value. W. S. Rogers. Experience with different systems of wage payment. Incidentally gain-sharing and profit-sharing are criticized. Serial. 1st part. 2400 w. Machinery—April, 1896.

Wages in the Engineering Trade. J. Stafford Ransome. Investigation of the inequalities in wages in different parts of Great Britain. Serial. 1st part. 2000 w. Engineer, London—April 3, 1896.

Recent Foreign Statistical Publications. General report on the wages of the manual labor classes in the United Kingdom, with tables of the average rates of wages and hours of labor of persons employed in several of the principal trades in 1886 and 1891. 5000 w. Bulletin Dept. of Labor—May, 1896.

Piece-work vs. Day's Work. Robert Grimshaw. Shows that what might be best for one shop or set of men might prove a failure under different circumstances. 1400 w. Railroad Car Journal—Jan., 1897.

Fair Wages. Editorial discussion of the report by the Select Committee appointed to consider the working of the Fair Wages Resolution passed by House of Commons. 2500 w. Engineering—Nov. 26, 1897.

Rates of Wages and Hours of Labor. Comments on information given in the recent report of the Commissioner of Labor on "Changes in Rates of Wages and Hours of Labor in the United Kingdom." 1800 w. Journal Gas Lighting—Aug. 23, 1898.

Wages and Hours of Labor. Editorial on the report from the Labor Dept. of the British Board of Trade, urging the desirability of avoiding fluctuations in wages. 2000 w. Engineering—Aug. 26, 1898.

The Evolution of High Wages from Low Cost of Labor. Edward Atkinson. Read before Am. Assn. for the Advancement of Science. 5500 w. Appleton's Popular Science Monthly—Oct., 1898.

Some Valuable Wage Statistics. Considers statistics given in Sept. number of the "Bulletin of the U. S. Dept. of Labor." 2000 w. Gunton's Mag.—Jan. 1899.

*Systems for the Remuneration of Labor. P. J. Darlington. A critical examination of the claims of the premium system, in comparison with the piece-rate method, showing the deficiencies of the former. 4500 w. The Engineering Magazine—Sept., 1899.

Piece-Work and Premium Plan. R. T. Shea. Opposed to the premium plan, and favoring piece-work. Also editorial. 2500 w. Locomotive Engineering—Jan., 1900.

Wages Paid Mechanics in the Private Shipyards of Foreign Nations. Information of importance from a standpoint of competition in vessel construction. 2200 w. Marine Engineering—May, 1900.

*New Shop Methods a Corollary of Modern Machinery. Editorial showing that labor's opposition to the new wage system is like its former opposition to machinery, and equally futile. Improved machinery and intensified production are parts of the same movement. 1800 w. The Engineering Magazine—June, 1900.

*The Application of Piece Work and the Premium Plan. Sir B. C. Browne. A discussion of the importance and relative fields of the premium and piece-work systems from a British view-point. 3300 w. The Engineering Magazine—Feb., 1901.

The Economic Status of Wages. Edward Howell Putnam. A discussion of this subject, especially as applied to foundry work. 5400 w. Journal American Foundrymen's Assn.—June, 1901.

What Shall Fix Fair Wages? Editorial discussion of what is a fair wage, with reference to strikes and other labor problems. 2000 w. Engineering News—Aug. 1, 1901.

Compensation of Skilled Labor. J. Richards. Discussion of this subject by one who is himself a practical workman and who has large experience in directing work and arranging compensation, etc. 6500 w. Journal Assn. of Engineering Societies—March, 1902.

The Inefficiency of the Wages System. Discusses wages system in England and the possibility of improving or superseding it. 2800 w. Journal Gas Lighting—May 27, 1902.

History of the Sliding Scale. From the *South Wales Daily News*. 1500 w. Iron & Coal Trades Review—Aug. 8, 1902.

*The False Economy of a Low Wage Rate. Percy Longmuir. Showing the inefficiency of cheap labor, and the wastefulness of ill-nourished workers, as compared with the productiveness of higher paid workmen. 3500 w. The Engineering Magazine—Nov., 1902.

*The Real Economy of a High Wage Rate. Percy Longmuir. A discussion of the effect of a high wage rate as a stimulus to the industry and capacity of skilled workers, and hence as an undoubted source of economy to the employer. 3000 w. The Engineering Magazine—Dec., 1902.

Gift Propositions for Paying Workmen. Frank Richards. Discusses the premium plan and the bonus system, and gives the writer's views. 3000 w. Trans. American Society of Mechanical Engineers, No. 0966—Dec., 1902.

Experience with the Premium and Piece-work Systems. R. J. Sutton. Discusses the attitude of labor organizations. 2400 w. Iron Trade Review—Sept. 3, 1903.

Plan to Establish a Machine Rating in a Locomotive Machine Shop, with Special Reference to New Tools. J. F. De Voy. Explains a system of card rating, giving information relative to the work to be performed. General discussion. 7500 w. Proc. Western Railway Club—Dec. 15, 1903.

Piece-Work, Premium and Bonus Systems. Harrington Emerson. Contribution to the discussion of a paper by Frank Richards, at Dec. meeting of American Society of Mechanical Engineers. 2000 w. Railroad Gazette—Jan. 15, 1904.

High Unit Labor Cost and Its Effect on Prosperity. Thomas D. West. 2500 w. Iron Trade Review—March 17, 1904.

Exact Time Study as the Basis of Pay for Work Done. H. L. Gantt. Read at the Philadelphia meeting of the National Metal Trades Assn. The difficulties of adjusting the payment of labor, and the effect on the output of plants. 2800 w. Iron Trade Review—March 31, 1904.

*Wage-Paying Methods from the Viewpoint of the Workman. Henry Hess. A graphical comparison of day-rate piece-work, bonus, and premium systems. 3500 w. The Engineering Magazine—April, 1904.

*Wage-Paying Methods from the Viewpoint of the Employer. Henry Hess. Discussion, with diagrams. 3000 w. The Engineering Magazine—May, 1904.

Wage-Paying Methods from the Viewpoint of Invested Capital. Henry Hess. Discussion, with diagrams. 2200 w. The Engineering Magazine—June, 1904.

Estimating Time for Lathe Work. Henry Hess. Methods in use, with charts. 3000 w. Machinery—May, 1904.

A Rational Basis for Wages. Harrington Emerson. Discusses what it is that the wage earner has to sell and why he should be paid for extra skill, and special devotion to his work. 4800 w. Trans. American Society of Mechanical Engineers, No. 022—June, 1904.

Bonus System.

A Bonus System of Rewarding Labor. H. L. Gantt. Describes a system of wages used in the machine shop of the Bethlehem Steel Co., in which a bonus is given when a job is completed within a certain time which has been fixed after careful experiments. 600 w. Trans. American Society of Mechanical Engineers, No. 928—Dec., 1901.

The Bonus System of Rewarding Labor. H. L. Gantt. Explains the work of Mr. Fred. W. Taylor, as this system was an outgrowth from his investigations, showing the advantages and the working of the system. 2000 w. Review of Reviews—Sept., 1902.

Equitable Labor Compensation and Maximum Output. H. L. Gantt. Principles and application of the bonus system. 3500 w. Cassier's Magazine—April, 1904.

Piece Work.

Piece-work on Locomotives. Classification for piece-work for an 8-wheel passenger locomotive as adopted by a leading railroad. Railroad and Engineering Journal—Jan., 1892.

A Piece-work System. F. W. Taylor. Reviewed above. Trans. American Society of Mechanical Engineers, No. 647, Vol. XVI—June, 1895.

*A Piece-Rate System and Workshop Management. Fred. W. Taylor. An article favoring payment of labor at rates determined by analysis of the labor. 4300 w. The Engineering Magazine—Jan., 1896.

Piece Work in Car Shops. G. L. Potter. A paper before the Western Railway Club, discussing the application of piece work to repair work especially, the conclusion being strongly favorable to the system. Illustrations of actual practice and of the forms in use in standard car shops. 2300 w. Railroad Car Journal—April, 1896. Also abstract in Railway Review, March 28, 1896.

The Piece-Work System. The system adopted by the Baltimore and Ohio Railroad is explained and a schedule of prices paid for a large number of separate parts is presented. 600 w. Railway Master Mechanic—April, 1896.

Machinists' Piece Work. M. S. Link. The piece-work system, while admitted to place workmen in their highest working capacity, is condemned as gradually extinguishing the grade of good all-around machinists. 1500 w. Machinery—Oct., 1896.

Piece Work in Repair Shops. C. F. Uebelacker. States the conditions which led to the adoption of the piece-work system, how the problem of working up a price list was solved, and general details. 3000 w. Street Railway Journal—Dec., 1896.

How Can the Elementary Rate-Fixing be Best Attained for Use in Establishing Piece-Work Prices in the Railway Paint Shop? Papers by Messrs. Ball and Lanfersick before the American Master Car and Locomotive Painters' Association. 2400 w. Railroad Car Journal—Oct., 1897.

Regarding Piece Work. Editorial discussion of the advisability of adopting the piece-work system in railway shops. 1800 w. Railway and Engineering Review—Nov. 11, 1899.

*Piece Work Not Essential to Best Results in the Machine Shop. James O'Connell. An official statement of the attitude of American organized labor. 3600 w. The Engineering Magazine—June, 1900.

*Piece Work as an Agency in Machine-Shop Cost Reduction. M. Cokely. Showing the logic and necessity of a wage system providing reward and penalty. 3000 w. The Engineering Magazine—Nov., 1900.

*The Taylor Differential Piece-Rate System. Sanford E. Thompson. An exposition of the method of fixing piece rates which has proved so successful in large establishments in the United States. 5000 w. The Engineering Magazine—Jan., 1901.

Piece Work. Its Evils and Remedies. Gilbert Fox. Discusses this system and its working. 2200 w. Practical Engineer—Jan. 10, 1902.

Theory of Compensation of Labor. A discussion of the proper way to introduce piece-work systems in railroad shops. Serial. 1st part. 1600 w. American Engineer and Railroad Journal—March, 1902.

Time Required to Turn a Piece. Robert Grimshaw. Information concerning the time required to perform machine-tool operations. 1000 w. Iron Trade Review—Sept. 4, 1902.

Piece Work in a Locomotive Erecting Shop. J. Korns. Gives suggestions based upon successful experience. 1000 w. American Engineer and Railroad Journal—Dec., 1902.

Piece Work in Railway Shops. Gus Giroux. Read before the Canadian Railway Club. Shows the advantages of this system and gives suggestions for introducing it. 3500 w. Railway Age—Dec. 26, 1902.

The Piece-Work System from a Piece-Workers' Standpoint. H. B. Kepner. The first of a series of articles discussing the advantages and disadvantages of the system. Serial. 1st part. 1300 w. American Engineer and Railroad Journal—June, 1903.

*A Remodeled Piece-Work System. John H. Van Yorx, Jr. A practical working description of a plan designed to give a maximum of the necessary detailed information with a minimum of clerical work by any of the shop employees. Illustrated with fac-similes of all the forms used. 4000 w. The Engineering Magazine—Aug., 1903.

Inspection and Quality of Product in Piece Work. Translated from the *Gewerblich-Technischer Ratgeber*. Describes methods of testing and forms of penalties for bad work. 2500 w. American Machinist—Aug. 13, 1903.

The Fixing of Piece-Work Rates. Hugo Diemer. Details of experience in the accurate fixing of piece-work rates and the determination of speed records. 3000 w. The Engineering Magazine—Nov., 1903.

Is Anything the Matter with Piece Work? Frank Richards. A discussion of the merits of "piece work" and of the "premium plan." 2000 w. Trans. American Society of Mechanical Engineers, No. 01—Dec., 1903.

Premium Plan.

The Premium Plan of Paying for Labor. F. A. Halsey. Reviewed above. Trans American Society of Mechanical Engineers, No. 449, Vol. XII—June, 1891.

Experience with the Premium Plan of Paying for Labor. F. A. Halsey. Outlines the plan which was described eight years ago, and presents data concerning its working in a well-known manufacturing corporation, which has had it on trial for two years. 4000 w. American Machinist—March 9, 1899.

Some Questions Regarding the Premium Plan with Answers to Them. F. A. H. Discusses the applicability of the plan to stated conditions. 1800 w. American Machinist—March 23, 1899.

The Administration of the Premium Plan. F. A. Halsey. How the plan is carried out in some of the shops where it is used. Serial. 1st part. 1800 w. American Machinist—July 6, 1899.

The Premium Plan at the Works of A. L. Ide & Sons. Herman Fernstrom. Describes the system used at these works, considering it more simple than most others. 2200 w. American Machinist—Sept. 7, 1899.

The Reference or Premium Plan. Isaac Ross. An explanation of a system that has been worked successfully for seven years. 1500 w. American Machinist—Dec. 7, 1899.

*Actual Experience with the Premium System. H. M. Norris. An account of an attempt to introduce the premium system into an American works and the obstructive attitude assumed by union labor. Two parts. 5000 w. and 3500 w., respectively. The Engineering Magazine—Jan. and Feb., 1900.

The Economics of the Premium Plan. F. A. Halsey. Abstract of a lecture before the Providence Society of Mechanical Engineers. An explanation of the system, giving figures and statements from representative concerns in its support. 3200 w. American Machinist—May 3, 1900.

The Determination of Time Limits Under the Premium Plan. George H. Hall. 1600 w. American Machinist—July 12, 1900.

*The Premium Plan of Labor Remuneration. H. M. Norris. An account of the practical working of the premium system under the immediate supervision of the writer. 4000 w. The Engineering Magazine—Jan., 1901.

Spoiled Work—Inspection and the Use of Limits Under the Premium Plan. G. H. Hall. Advocating the charging of the workman with the time required to rectify spoiled work, and work beyond the established limits of variation. 1700 w. American Machinist—Feb. 14, 1901.

A Premium System of Remunerating Labor. James Rowan. Describes a premium system of wage-payment used in marine engine manufacture. 2400 w. Inst. of Mechanical Engineers—Glasgow Congress, 1901. Also abstract in Iron and Coal Trades Review—Sept. 6, 1901.

Premium Plan of Rewarding Labor. H. M. Norris. Stenographer's report of paper read before the Engine Builders' Assn. An explanation of the system as introduced at the works of the Bickford Drill & Tool Co., Cincinnati, Ohio. 4800 w. Engineer, U. S. A.—Jan. 1, 1902. Special number.

The Premium Plan at the Works of David Rowan & Company, Glasgow, Scotland. James Rowan. Also "The Origin of the Premium Plan." A personal statement by F. A. Halsey. Descriptive article. 3700 w. American Machinist—Jan. 9, 1902.

The Premium System. An explanation of the system, discussing its advantages, and the workmen's objections, and hoping to consider every phase of the question. Serial. 1st part. 2000 w. Engineer, London—Jan. 24, 1902.

The Premium Plan at the Works of David Rowan & Company—Piece Work, the Premium Plan, and Mr. Taylor's Plan Discussed. E. G. Herbert. 2200 w. American Machinist—Feb. 20, 1902.

The Premium Plan of Paying for Labor. F. A. Halsey. An explanation of this system and a discussion of its advantages and disadvantages. 7000 w. Sibley Journal of Engineering—Mar., 1902.

The Premium Plan at the Blank Blank Engineering Works. Gives figures showing in detail and in summary the workings of the premium plan as a whole in a plant which employs about four hundred men in all departments. 2000 w. American Machinist—June 26, 1902.

The Premium System of Wages (Das Prämiensystem der Arbeiterlohnung). F. Preuss. A general discussion of the premium system, with dia-

grams comparing day's work and piece work with the systems of Halsey and of Rowan. 2500 w. Zeitschrift des Vereines Deutscher Ingenieure—Jan. 31, 1903.

The Premium Plan from the Workman's Standpoint. F. A. Halsey. Extracts from an address before the Civic Federation. Gives opinions from various points where the system has been tried, all favorable to its working. 2000 w. American Machinist—Feb. 5, 1903.

A Premium System Applied to Engineering Workshops. James Rowan. Gives facts gained in an experience of five years' working of the system. 4500 w. Institution of Mechanical Engineers—March 20, 1903.

A Modification of the Premium Plan. W. H. Booth. A discussion of methods of adjusting rates, with editorial criticism. 1800 w. American Machinist—April 16, 1903.

The Premium System of Remunerating Labor. John Ashford. Read before the Manchester (Eng.) Assn. of Engineers. Explains the principle of this system and the features that have developed in its working. Serial. 1st part. 3400 w. Mechanical Engineer—April 18, 1903.

*Cost Reduction by the Use of the Premium Plan. C. A. Colwell. An account of five months' practical experience in a large shop. Gives some very interesting data of cost reduction by the use of the new tool steels. Illustrated. 4000 w. The Engineering Magazine—May, 1903.

The Premium System of Wages (Das Prämiensystem der Lohnberechnung,) B. Schiller. A scientific examination of the Halsey premium system in comparison with day wages, also considering the Rowan modification and a method of the writer, together with piece work. 7500 w. Zeitschrift des Vereines Deutscher Ingeniure—Aug. 22, 1903.

The Premium System in Practice. Charles B. Cook. An explanation of the system as used in a factory. 1700 w. Iron Trade Review—Dec. 3, 1903.

A German View of the Premium Plan. B. Schiller. Abstract of a paper in the Zeitschrift des Vereines Deutscher Ingenieure, containing a critical examination of the Halsey premium plan. Serial. 1st part. 2500 w. American Machinist—Feb. 18, 1904.

*The Premium Plan of Wage Payment in a Repair Shop. Albert W. Thompson. A description, illustrated with forms, of the system which is used for part of the work done in the repair shops of the Amoskeag and Manchester, N. H., textile mills. 1500 w. The Engineering Magazine—June, 1904.

Profit Sharing.

Gain Sharing. H. R. Towne. Reviewed above. Trans. American Society of Mechanical Engineers, No. 341, Vol. X—May, 1889.

Experience with Profit Sharing. An editorial reviewing principally American experiments in this line, and pointing out the limitations. The piece-work system is considered preferable. 4500 w. Engineering—Dec. 27, 1895.

Both Sides of Profit Sharing. Frederic G. Mather. The system discussed and many examples cited where the benefits have been mutual, but concluding that neither profit sharing nor any other device will improve the situation, if there is lack of sympathy on either side toward the others. 3500 w. Popular Science Monthly—Jan., 1896.

Profit Sharing in the United States. Paul Monroe. An account of results in some fifty different establishments in the United States wherein the experiment has been tried. The conclusion is that such a system will succeed only with a select few of employers and with a certain grade of skilled or intelligent labor. 11000 w. American Journal of Sociology—May, 1896.

Profit Sharing at Ivorydale. I. W. Howerth. Presents the salient features and the results of profit sharing at the Procter & Gamble Company, engaged in the manufacture of soap, candles and glycerine at Ivorydale, Ohio. 4500 w. American Journal of Sociology—July, 1896.

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A Dividend to Labor. J. Holliday. Read before the North of England Gas Managers Assn. A few ideas on the subject of profit sharing as relating particularly to gas undertakings. 2500 w. Journal Gas Lighting—April 29, 1902.

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GENERAL MANAGEMENT.

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*Six Examples of Successful Shop Management. Henry Roland (H. L. Arnold). A series of articles in the Engineering Magazine—Oct., Nov., Dec., 1896, Feb., March and April, 1897.

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*Labor-Saving Machinery, the Secret of Cheap Production. A. E. Outerbridge, Jr. Showing that an ascending wage-scale is an essential of prosperous productivity. 3200 w. The Engineering Magazine—Jan., 1897.

An Unique Manufacturing Establishment. The first of a series of articles purposing to give an idea of the factory of the National Cash Register Co., of Dayton, O., and of the spirit that pervades it. Illustrated. Serial. 1st part. 4500 w. American Machinist—March 25, 1897.

Manufacturing Methods as Applied to the Production of Machinery. F. A. Halsey. The methods described relate specially to manufacture by aid of special fixtures, and refer to pure machine-shop operations only. 3300 w. Sibley Journal of Engineering—June, 1897. Also abstract in American Machinist—Aug. 19, 1897.

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A New Shop System. George D. Chapman. Describes the system in operation the past two years at the shops of the Fitchburg Machine Works, in Massachusetts, where tools are manufactured. Ill. 2200 w. Machinery, N. Y.—March, 1898.

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A Decade of Progress in Reducing Costs. C. Kirchhoff. Presidential address before Am. Inst. of Mining Eng'rs. Improvements which have made great reductions in cost in iron, steel and other metallurgical industries. 3800 w. Trans. American Institute of Mining Engineers—Feb., 1899. Also in Iron Age—March 2, 1899.

The Laws of Profit. R. H. Smith. An examination of the elementary general laws that govern profit-making business. Serial. 1st part. 3500 w. Engineer, London—Sept. 8, 1899.

*Standardizing in Engineering Construction. Sir Benjamin C. Browne. A series of three papers. The Engineering Magazine—Oct., Nov. and Dec., 1899.

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*A Practical View of Machine-Shop Conditions in the United States. M. Cokely. A study of the relations between employer and employee, showing that the true solution of the problem lies in cheap production. 3000 w. The Engineering Magazine—Aug., 1901.

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*American Machine-Shop Practice from a German Viewpoint. Peter Lüders. Two papers discussing American manufacturing conditions, the equipment of the shops, organization, and the unity of engineer and workman. 2400 w. and 4000 w. The Engineering Magazine—Sept. and Nov., 1901.

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Andrew Carnegie's Presidential Address to the Iron and Steel Institute. Extracts from the address in London, referring to the relations of capital and labor. 5800 w. Iron Age—May 7, 1903. Also in Engineering News—May 14, 1903; and Cassier's Magazine—July, 1903.

Hunt Measurements and Drawings. John Randol (H. L. Arnold). Illustrated articles describing the method of making measurements in machine work used by the C. W. Hunt Co. Serial. 1st part. 2800 w. American Machinist—May 21, 1903.

High-Speed Metal Cutting. Oberlin Smith. Discusses the recent improvements in tool steel, and the consequent improvement needed in machine tool design; considers the planer problem. 2000 w. American Machinist—May 21, 1903.

The Ideal Foreman. William Lodge. Address before the convention of local employers' associations at Cincinnati. Considers the requirements for a successful foreman, and gives suggestions. 8000 w. Iron Age—May 28, 1903.

*Purchase by the Organized Factory. Horace L. Arnold. A concise description of a practical system, in regular use, for ordering supplies into the factory, checking their receipt and issue by the storekeeper, and safeguarding the payment of every invoice. The system is simple and almost automatic. Illustrated. 3000 w. The Engineering Magazine—June, 1903.

*The Promotion of Industrial Efficiency and National Prosperity. John B. C. Kershaw. A series of three articles. The Engineering Magazine—June to August, 1903.

No. 1. Methods for bringing employers and employees into closer accord, with brief descriptions of the plans in use at a large number of successful works in America and Europe. 5500 w.

No. 2. Past hindrances and a suggested modification of the premium plan. A comparative study of profit-sharing, premium and bonus systems. 2600 w.

No. 3. The future, and trades-union hostility. 2500 w.

Shop Management. Fred W. Taylor. An exhaustive treatise on some of the different systems of shop management, including methods of timing the rate of work, the amount of the day's work and the methods of rewarding the laborers. 47500 w. Trans. American Society of Mechanical Engineers—June, 1903.

A Machine-Shop Problem. Charles Day. A discussion of points in connection with the equipment and management of manufacturing establishments. 5500 w. Trans. American Society of Mechanical Engineers—June, 1903.

The Decentralization of Factories. T. C. Elder and Herbert J. Scoble. Gives a presentation of existing conditions and discusses the "Garden City" scheme proposed by Mr. Ebenezer Howard, and the "Industrial Redistribution" pamphlet, by W. L. Magden, with special reference to England. Serial. 1st part. 6700 w. Traction & Transmission—June, 1903.

Modern Manufacturing Methods. Editorial on the methods of management demanded by modern machines if they are to prove a paying investment. 2200 w. Engineering—June 5, 1903.

Gauges in Workshops. Herbert J. Marshall. Read at the Engng. Con. of the Inst. of Civil Engrs. A discussion of gauges and standards as affecting shop and manufactory administration. 2000 w. Engineering—June 19, 1903.

*The Commercial Management of Factories. Ian Andrews. A synopsis of the influence and functions of the office manager in relation to the reduction of the cost of output. 3100 w. The Engineering Magazine—July, 1903.

Workmen's Insurance in Germany (Die Deutsche Arbeiter-Versicherung). Fr. Pichler. Paper before the Technischer Verein of Baltimore, giving an account of the system of workmen's insurance instituted by the German government, in which both employer and employee contribute to the fund. Diagrams. 3000 w. Technologist—July, 1903.

A Journey in the United States for the Purpose of Studying the Mechanical Industries (Eine Studienreise in den Vereinigten Staaten von Amerika). Paul Moeller. An account of American technical and industrial conditions, by a representative of the Verein Deutscher Ingenieure. Serial. 2 parts. 7000 w. Zeitschrift des Vereines Deutscher Ingenieure—July 4 and 11, 1903.

Shop and Sales Systems of the C. W. Hunt Co. John Calder. Charts and explanatory notes. 1200 w. Iron Trade Review—Aug. 6, 1903.

American and British Workmen. A comparison, discussing their behavior and surroundings. Serial. 1st part. 4700 w. Engineering—Aug. 14, 1903.

The Age of Machinery and Its Relation to Public Welfare (Das Maschinenzeitalter in seinem Zusammenhang mit dem Volkswohlstand und der Sozialen Verpassung der Volkswirtschaft). Gustav Schmoller. An address delivered before the Munich convention of the Society of German Engineers showing the great influence of machinery upon civilization. 6000 w. Zeitschrift des Vereines Deutscher Ingenieure—Aug. 15, 1903.

*The Issues Between Labor and Capital. Egbert P. Watson. An impartial discussion of the faults of trade unionism and the mistakes of employers. 3000 w. The Engineering Magazine—Oct., 1903.

A Tool-Room System. Describes a system in operation in one of the large works in the United States. 1800 w. American Machinist—Oct. 15, 1903.

*The Ethics of Workshop Management. Egbert P. Watson. A discussion of actual working relations between employers and men in the shop, based on extended experience. 2000 w. The Engineering Magazine—Nov., 1903.

What Are the New Machine Tools to Be? John E. Sweet. Considers machine design, and the capabilities of high-speed steel. 1500 w. Trans. American Society of Mechanical Engineers, No. 04—Dec., 1903.

Modifying Systems of Management. H. L. Gantt. Gives opinions on methods advocated by Mr. Taylor at the Saratoga meeting. 1300 w. Trans. American Society of Mechanical Engineers, No. 014—Dec., 1903.

Slide Rules for the Machine Shop as a Part of the Taylor System of Management. Carl G. Barth. 3800 w. Trans. American Society of Mechanical Engineers, No. 013—Dec., 1903.

Machine Tools and High-Speed Steel. J. A. Carney. Considers what shall be done with serviceable tools which cannot maintain the high-speed-steel pace. General discussion. 4000 w. Proc. Western Railway Club—Dec. 15, 1903.

The Modern Tool Room. Fred H. Holz, Jr. Read before the Cincinnati Metal Trades Ass'n. Suggestions for facilitating work in this department. 1700 w. Iron Trade Review—Dec. 17, 1903.

*Cutting Speeds and Feeds with the New Tool Steels. Oberlin Smith. A summary of practical experience with high-speed steels in the workshop, showing their great advantage. 2500 w. The Engineering Magazine—Jan., 1904.

The Commercial Side of Engineering. Walter M. McFarland. Emphasizes the necessity of judgment, discusses effect of cost, and shows that "good enough" is better than "too well." 7800 w. Cassier's Magazine—Jan., 1904.

*The Effects of Labor-Saving Machinery. Frank H. Rose. Showing such machinery to be beneficial to both employer and employee. 4000 w. The Engineering Magazine—March, 1904.

Points in Shop Management. Frank B. Kleinhans. Discusses the uses of the grinding machine, the lining up of work, etc. Ill. 2200 w. Iron Trade Review—March 3, 1904.

How Machine Tools Are Developed. John Randol (H. L. Arnold). A criticism of the methods of machine-tool builders. 1800 w. American Machinist—March 24, 1904.

Staff and Departmental Organization. Hugo Diemer. Remarks on the advantages of organization, and suggestions for making a study of the most suitable system. 1800 w. Iron Trade Review—May 5, 1904.

Equipment and Plant.

Neglected Possibilities of the Modern Machine Shop. Editorial suggestions on planning, arranging and equipping. 700 w. American Machinist—Nov. 28, 1895.

A Modern Industrial Plant. Detailed description of the soap-manufacturing establishment of Procter & Gamble, near Cincinnati, with illustrations of buildings, details of roofs, floors and various apparatus. Engineering Record—May 2, 1891.

*Healthful Air in Factory Buildings. Walter B. Snow. A plea for pure air in factories and illustrated descriptions of ventilating and heating apparatus. 3500 w. The Engineering Magazine—July, 1891.

*Modern American Machine Tools. Oberlin Smith. A review of development and forecast of the future. 3000 w. The Engineering Magazine—Oct., 1894.

*Modern Machine-Shop Economics. Horace L. Arnold. Pointing out the considerations that should govern shop locations. 3700 w. The Engineering Magazine—April, 1896.

The Choice of Location for Manufacturing Plants. Editorial in which the success of a manufacturing industry is considered as depending upon abundant capital, good location, the most modern machinery, and good management, with a tabulated statement of the location of the principal manufacturing industries in the United States. 4000 w. Engineering News—April 9, 1896.

The Works of the American Tool Works Company. Illustrated description of these works, the departments, methods, packing, show cabinets and processes. 3000 w. Iron Age—April 21, 1898.

Some Considerations Affecting the Location and Design of Machine Shops. Concerning the new shops of the Lane and Bodley Co., of Cincinnati. 1500 w. American Machinist—Sept. 28, 1899.

Comfortable Work Shops. Editorial on the profitableness of keeping shops comfortably warm, well lighted, in good sanitary condition, etc. 1700 w. Iron Age—Nov. 8, 1900.

*Shop Arrangement as a Factor in Efficiency. H. F. L. Orcutt. A discussion of the design of an engineering works as a great tool, by the designer of the works of Ludwig Loewe & Co., of Berlin. 3000 w. The Engineering Magazine—Jan., 1901.

*The Economy of Heating and Ventilating the Machine Shop. L. Allen. A discussion of the influence of personal comfort upon individual efficiency, showing how bad hygienic conditions reduce quality and rate of output. 3000 w. The Engineering Magazine—April, 1901.

The Ventilation, Lighting and Cleanliness of Small Workshops. John Robertson. 3000 w. Plumber and Decorator—Dec. 2, 1901.

Bricklaying at the British Westinghouse Works. J. C. Stewart, in the London *Times*. Explains the method adopted to double and triple the rate of bricklaying per man in Great Britain. 1700 w. Engineering Record—March 29, 1902.

The Plant of the Bullock Electric Manufacturing Company and Its Work and Cost System. Illustrated detailed description of one of the finest modern plants, located near Cincinnati, and its methods. 5000 w. Iron Trade Review—April 3, 1902.

Messrs. David Rowan and Co.'s Works, Glasgow. An illustrated detailed description, with discussion of the engineering economy in the management of such works. 5400 w. Engineering—May 9, 1902.

The German Niles Tool Works, Berlin. Begins an illustrated detailed description of these interesting works, where American and German systems of engineering are combined. Serial. 1st part. 5600 w. Engineering—May 30, 1902.

Shop Construction. Oscar E. Perrigo. The first of a series of illustrated articles upon the design and construction of machine shops, with hints upon the arrangement of tools, and the management. Serial. 1st part. 2200 w. Machinery, N. Y.—Oct., 1902.

The Ventilation of Workshops. Reviews the first report of the Commissioners inquiring into the ventilation of factories and workshops. Deals only with general ventilation. 2200 w. Iron & Coal Trades Review—Nov. 7, 1902.

Notes on the Krupp Works (Einiges über Krupp). A brief review of the development of the Krupp works, with plate of illustrations showing views in the works and plans and elevations of the workmen's houses. 1200 w. Oesterreichische Zeitschrift für Berg und Hüttenwesen—Nov. 29, 1902.

The Designing and Construction of Modern Engineering Workshops. J. H. Humphreys. Read before the Manchester (England), Ass'n of Engrs. An illustrated discussion of stanchions, crane girders, floors, and floor girders, roof principals, and bracing. Serial. 2 parts. 4500 w. Mechanical Engineer—Dec. 13 and 20, 1902.

The Ventilation of Factories. Abstract of the "First Report of the Departmental Committee Appointed to Inquire Into the Ventilation of Factories and Workshops," with editorial comment. 3000 w. Engineer, London—Jan. 9, 1903.

The Laying Out of Engineers' Workshops. Joseph Horner. The first of a series of articles concerning the conditions which should govern the arrangements dealing with extensions of old works, laying out of new, etc. Serial. 1st part. 3000 w. Page's Magazine—March, 1903.

Machine-Shop Equipment. Oscar E. Perrigo. The present article considers planning the different departments, suggesting the proper selection and arrangement of machines. Serial. 1st part. 3700 w. Ill. Machinery, N. Y.—Sept., 1903.

*The Tools and Methods of a Swiss Locomotive Works. C. R. King. An illustrated description of the Swiss Locomotive and Machine Works at Winterthur, showing a union of English, American and Continental practice. 3500 w. The Engineering Magazine—Sept., 1903.

A Model Bridge and Construction Shop. An illustrated detailed description of the Pennsylvania Steel Company's new plant at Steelton, Pa. 3500 w. Iron Age—Sept. 10, 1903.

The Pennsylvania Company's Model Bridge Plant. Part first gives an illustrated description of the general arrangement and principal features of the plant at Steelton, near Harrisburg, Pa. Serial. 1st part. 5700 w. Engineering Record—Sept. 26, 1903.

The Ambridge Plant of the American Bridge Company. An illustrated description of the arrangement, operation, power, transportation and buildings. Serial. 1st part. 5500 w. Engineering Record—Nov. 21, 1903.

Suggestions for Shop Construction. F. A. Scheffler. Describes a plan in which the various departments radiate from the administration building. Diagram. 900 w. Trans. American Society of Mechanical Engineers, No. 09—Dec., 1903.

Modern Workshop Design. A. Pringle. The bearing of the class of work upon the design and equipment of shops; the important features, the materials, roofing, etc., are discussed. 5200 w. Canadian Society of Civil Engineers, Adv. Proof—Dec., 1903.

The New Henry R. Worthington Hydraulic Works at Harrison, N. J. Illustrated description of a very large and complete manufacturing plant. Serial. 1st part. 5000 w. Engineering Record—Feb. 6, 1904.

Features of the Michigan Stove Company's Plant and Methods. Illustrated detailed description. 4000 w. Iron Trade Review—March 3, 1904.

The Economic Theory of Factory Location. Hugo Diemer. Discussion. 2000 w. Railway Age—March 18, 1904.

The Planning of Factory Buildings and the Influence of Design on their Productive Capacity. Hugo Diemer. Suggestions aiming to secure utility and economy, and with a view to future expansion. 3000 w. Engineering News—March 24, 1904.

Foundry.

*A Survey of Modern Foundry Practice. Percy Longmuir. Showing the defects of many of the older foundries and the remarkable cheapening in castings effected by the introduction of modern methods and machines. 5000 w. The Engineering Magazine—Jan., 1901.

Foundry Economy. Percy Longmuir. Briefly considers the requirements of economical castings, organization, and management. 2600 w. Iron Trade Review—March 28, 1901.

The Foundry, Its Equipment and Management. Edw. B. Gilmour. Discusses what a modern foundry should be when quantity and quick delivery are of greatest importance. Ill. 3000 w. Journal American Foundrymen's Ass'n—June, 1901.

Control of the Foundry. Percy Longmuir. On the relation of laboratory and foundry and the education needed by the manager. 1600 w. Jour. American Foundrymen's Ass'n—June, 1901.

*Opportunities for Bettering the Work of the Foundry. Percy Longmuir. States conditions as they often exist, showing that poor installations are costly, and discussing points leading to satisfactory and economical results. 3800 w. The Engineering Magazine—Oct., 1901.

The Engineer in the Foundry: A New Departure. An illustrated article prepared from the lecture of Samuel Groves, at the Buffalo Convention of the Amer. Foundrymen's Ass'n, showing the methods pursued in providing foundry appliances and equipment for the works of the Westinghouse Machine Company. 2800 w. Foundry—Dec., 1901.

Foundry Economy. Dr. Richard Moldenke. How the foundryman is to economize by the applications of scientific methods is discussed, and other suggestions are given. 2800 w. Jour. American Foundrymen's Ass'n—April, 1902.

The Relative Position of Employer and Employed. Edw. B. Gilmour. Arguments showing the interests are co-equal. 1100 w. Jour. American Foundrymen's Ass'n—May, 1902.

The Advantage of Working to Patterns and Gauges. Walter J. May. Calls attention to the advantages derived from the use of carefully made patterns and gauges in all cases where repetition work is likely to occur, especially in the foundry and smithy. 2000 w. Practical Engineer—May 30, 1902.

Some Methods of Increasing Foundry Productions. David Reid. Describes methods tried and proved successful. 1500 w. Jour. American Foundrymen's Ass'n—June, 1902.

Economy. P. R. Ramp. Calls attention to things that cause waste, and to false economy often practiced. 1400 w. Jour. American Foundrymen's Ass'n—June, 1902.

The Relation of the Molding Machine to Foundry Labor. C. H. Mumford. Address before the New England Foundrymen's Ass'n. Discusses the relation of the molding machine to union foundry labor. 3800 w. Iron Age—Nov. 20, 1902.

*Foundry Management in the New Century. Robert Buchanan. A series of seven articles. The Engineering Magazine—Dec., 1902, to June, 1903.

No. 1. The economical production of castings. Ill. 3500 w.

No. 2. Crane service and transport appliances for the foundry floor. Ill. 4500 w.

No. 3. Moulding by hand and by machine. Ill. 4500 w.

No. 4. Materials of consumption, including the purchase of coke, iron, sand, etc. Ill. 5000 w.

No. 5. The cupola and the principles involved in its successful and economical use. Ill. 4500 w.

No. 6. The dressing of castings. Ill. 3500 w.

No. 7. The qualities and training of the foundry manager. 2500 w.

Limitation of Output by Molders. James A. Murphy. Discusses the restriction of output and the attitude of the Molders' Union. 1700 w. Iron Trade Review—Dec. 4, 1902.

The Future of the Foundry Industry. Dr. Richard Moldenke. A discussion of the outlook and the labor questions involved. 2800 w. Jour. American Foundrymen's Ass'n—March, 1903.

Rigs as a Factor in Foundry Management. Edward Kirk. An article discussing the advantage of proper rigging. 1600 w. Foundry—April, 1903.

The Advantages of Having a Foundry Attached to an Existing Engineering Works in the Country. J. A. Coombs. Shows the effect in cost of castings and considers the subject generally. 1800 w. Practical Engineer—April 3, 1903.

The Organization, Maintenance and Management of a Modern Pattern Shop. Jos. Leon Gobeille. Discusses remedies and improvements needed. Ill. 1800 w. Jour. American Foundrymen's Ass'n—June, 1903.

Foundry Management. Edward Kirk. Describes conditions representing the management of fully half the foundries, and discusses improvements. 5200 w. Foundry—June, 1903.

The Equipment of the Foundry. Joseph Horner. An illustrated article discussing especially the general shop, with departments for special work. 5500 w. Cassier's Magazine—Oct., 1903.

*Labor-Saving Machinery in Foundry Operations. Dr. R. Moldenke. A fully illustrated account of the latest improvements in cranes, ladles, molding machines, conveyors, core machines, etc. 3500 w. The Engineering Magazine—March, 1904.

EDITORIAL COMMENT

THE first of our series of special numbers dealing with Labor-Saving Machinery and Methods, which appeared in March last, dealt with the fundamental element in the problem—the use of mechanical power. In this second of the group, the factors taken up are the problems of mechanical and commercial management which follow the centralization of manufacture and the intensified development of the factory system; the particular manifestation studied is that found in the machine shop—or the shop where metal cutting tools are used; for this is not only the most pertinent to the province of the Magazine, but it forms the broadest class of modern manufacturing industries. Whether the product be typewriters or engines for an Atlantic liner, many of the principles are identical; and whatever the factory may make, if it be a works of even medium size the machine shop will be the foundation of its maintenance at the point of greatest efficiency.

The concluding number of the series, which will appear later in the year, will take up a line of power applications which is perhaps the most diversified of all, and very widely useful in bettering the economy of manufacturing operations — Labor Saving by Mechanical Transport.

* * *

THE review of fire-prevention on shipboard which appears on page 678 of this number suggests one means by which such a horror as the Slocum disaster may, and very possibly will, be made far more unlikely of repetition. It is useless to talk of "the overwhelming censure of public opinion." Public censure—an ephemeral thing at most times—is of little effect against the incredible indifference and criminal negligence which open the way to such an "accident." Nor did anyone with eyes and ears need to be shown that "government inspection," under actual working conditions, becomes a mockery—hideous because of the false confidence it inspires in the multitude who might otherwise be warned to look more carefully after their own safety.

The one agency which can make, and enforce, rules which will minimize the risk is the Board of Underwriters. It has the force of a solid, coherent, and perfectly definite individuality to be dealt with. It has the practical efficiency of a sound business organization, using the best methods and the best talent the professions can supply. It has absolute power to enforce its rules under the penalty of withdrawal of insurance from those who violate them. And it cannot be bought, because there is no possible collusion with owners to the detriment of the public which would not yet more nearly betray the interest of the insurance companies themselves. When they awaken, as they are perhaps likely to do, to the conditions of the risks they are writing, and when they put this local marine business upon the same basis as they have adopted in other lines, there will be a set of rules

and a system of inspection which will mean something for the safety of the passenger.

* * *

WE have referred already in these columns to the visits of various foreign engineering societies to the United States, and it is a matter for much satisfaction to record the most successful joint meeting which was held last month in Chicago by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. The welcome presence of the president of the British Society, Mr. J. Hartley Wicksteed, as well as the secretary, Mr. Edgar Worthington, together with several members of the council, enabled the convention to be conducted in every respect as a joint meeting, both presidents officiating at all the sessions, and English and American members taking active parts in the discussions.

Some of the more important papers presented at the convention are reviewed elsewhere in this issue, but it is well understood that the most valuable feature of such gatherings is found in the opportunity afforded for the interchange of opinions, the making of acquaintances, and the acquirement of suggestion.

These advantages exist in a large degree even when the members belong to but one society, but they appear to a still greater extent when engineers from different countries, with varying methods and traditions, meet and mingle in the unconstrained and congenial manner so evident at Chicago. The "republic of letters" has often been cited as demonstrating the fact that there are no national limitations to the work of the writer, but there is also a republic of engineering, a republic in which the States are the great engineering societies of all civilized lands, and in which citizenship is attained only by achievement. When the members of such a republic meet in convention, there may be no procession, no brass bands, no demonstrations of political enthusiasm, but who shall say that the results of a convention of engineers, of men who do things, are not of greater and more lasting value to the nation and to the world than those which follow any political gathering?

* * *

THERE is a tendency in papers presented before engineering societies to use, or even abuse, the opportunity afforded to advance private interests by pushing individual devices, and this fact appeared to such a degree in certain of the papers presented at Chicago as to draw forth the sharp comment of more than one member during the discussion. This method of advertising appears more generally in the cases in which large corporations attempt to utilize the services of members of the soceity in their employ. The papers submitted by individual members are, as a rule, of far more technical value than these "inspired contributions." As a matter of fact the membership at large rates such efforts at their true value. The most desirable and valuable publicity is not to be obtained in this way. An audience is secured, it is true, but the interest of the paper is marred when there is the slightest feeling created that an attempt is being made to use a professional society in an unprofessional manner.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

A STEAM TURBINE SYMPOSIUM.

DE LAVAL, PARSONS, WESTINGHOUSE, CURTIS, AND RATEAU SYSTEMS COMPARED AND DISCUSSED.

American Society of Mechanical Engineers—Institution of Mechanical Engineers.

THE active interest which is felt in the development of the steam turbine is well shown by the fact that at the recent joint convention of the American and British mechanical engineers at Chicago there were four papers contributed by as many members, these occupying an entire session of the meeting for their presentation and discussion. The merits of the De Laval machine were shown by Mr. E. S. Lea, while Mr. Hodgkinson discussed very ably the contruction and operation of the Parsons turbine as made in the United States by the Westinghouse company. The Curtis turbine was described by Mr. Emmet, and in conclusion Professor Rateau gave a general account of the applications of turbines, together with a detailed review of his own work in this field. As every one of these engineers is actively connected with the practical construction and operations of these machines we thus have a most valuable collection of data and information at first hand.

Historically, the growth of the steam turbine may be traced in these papers in an interesting manner. De Laval, with the single impulse wheel, and Parsons, with the multiple turbine, combining both impulse and pressure, made their results public about twenty years ago, although Tournaire had described the multiple reaction turbine as long ago as 1853, while Branca, in 1629, described and illustrated a steam wheel with a single jet acting upon a wheel, and Kircher, in 1656, improved this by applying two jets to drive the same wheel. Neither of these early authors claimed any invention in these devices, rather describing them as ideas of current knowledge, and it is interesting to note that in Branca's original illustration the turbine is shown on a vertical axis, a form lately revived. Neither Branca nor Kircher appear to have made any such machines, both men being writers rather than constructors, but they seemed to have had fairly clear ideas for their time, Branca showing his wheel as being so geared to the machinery as to permit a high rotative speed of the turbine, which he evidently felt to be a necessity. In view of the accurate mechanical workmanship and high quality of materials necessary for the practical construction of satisfactory machines it is not to be wondered that the turbine, thus early conceived, should have been laid aside for more readily constructed forms of the steam engine, while now that the fundamental principles have been made public we may expect a rapid development similar to that which followed the general entrance of manufacturers into the field of dynamo construction under like circumstances. The good work which has been done by Parsons and by De Laval in rendering the steam turbine a practical machine is well indicated by the fact that the *Verein Deutscher Ingenieure*, at its recent meeting at Frankfurt am Main, has bestowed the award of the Grashof medal upon both engineers.

The general statement of the problem is well made by Mr. Emmet, when he says:

"The expansive force in steam is capable

of imparting to the steam itself very high velocities, and the problem which presents itself to the designer of steam turbines is to devise means by which the velocities of moving jets or columns of steam may be made to give up their work effectively to mechanical parts which run at practical speeds."

This problem of converting the high velocity of the steam jet into mechanical work, brings the engineer into contact with several fundamental principles. Thus, the maximum efficiency of a wheel is attained when the buckets upon which the steam acts travel at one-half the velocity of the steam which propels them. Again, the limit of rotative speed of a turbine wheel is that of the resistance of the material to the stresses due to centrifugal force. Moreover, high angular velocities require reduction by some form of gearing in order that the power may be applied to the machines which it is desired to drive. With these elements the designer also encounters the problems involved in the construction of steam nozzles which shall provide for the conversion of the expansion of the steam into velocity in a direction available for use upon the wheel. When it is considered that we really know very little about the actual behavior of steam jets in nozzles, or the losses due to friction, eddies, and internal work, it will be seen that there is yet ample room for experimental investigation and study of the elements of this most interesting problem. All the contributors to the symposium bear tribute to the excellent work which has already been done in this line by Professor Stodola, in the laboratory of the Zurich Polytechnikum, and it is to be hoped that such scientific researches will be continued and the results applied in future practical work.

Probably the most interesting feature of all in the various papers presented at the Chicago convention is the fact that the tests of the different machines under consideration show about the same steam consumption, this ranging from 14 to 16 pounds per brake horse-power hour, according to conditions. In view of such results it is evident that further lines of improvement may be expected along constructive details, since questions of convenience, size, weight, first cost, depreciation, etc., must become of controlling importance.

Higher steam economy has been attained by the reciprocating engine under special circumstances, but only with engines of large size and greater complication. When the comparison comes to be made upon the basis of economy, not merely of steam, but of money, and upon engines of moderate size, it may well be believed that any one of the turbines now on the market will make a better showing than the reciprocating engine. Indeed, it was emphasized in the course of the discussion that steam economy is a matter which is by no means always considered. Notwithstanding the high performances of the best forms of automatic and multiple-expansion steam engines there are large numbers of plain slide-valve engines built and sold every year, and these engines are bought and used by men who know very well what they are about. If it can be made to appear that the turbine, built upon any approved system, and bearing any name whatever, will give the maximum efficiency in the practical operation of converting value into more value, be it expressed in terms of money or any other equivalent, the nature of the stages of which this ultimate performance is made up become of secondary importance and interest.

For the engineer, of course, these secondary stages must be considered as falling largely to his share of the whole, and in this respect the paper of M. Rateau is of much value. Devoting a comparatively small portion to the publicity of his especial variety of machine, he shows how the turbine can be applied to the successful driving of machines as desirable as itself. The turbine makes it possible to use high-pressure centrifugal pumps, or similar blowing engines, replacing the ponderous machines now so familiar in waterworks, furnaces and mines. Thus, steam turbines, direct connected to multiple centrifugal pumps, are in operation in Bohemia, raising 400 to 600 gallons per minute against a head of more than 700 feet, with a steam consumption of less than 30 pounds per horse power measured in water lifted, this performance thus including the work of the turbine, as well as the pump and pipe resistances. When this result is compared with that of direct-acting steam pumps, including interest and depreciation, it will be seen that the turbine offers possibilities far beyond those of its own steam consumption. Fan

blowers, driven by steam turbines, have been effectively employed in France for supplying wind to blast furnaces under a pressure of four to five pounds per square inch at a rate of more than 100 cubic feet per second, with a total combined efficiency of more than 38 per cent., not taking into account the difference in interest on first cost.

When we compare the transformation which was made by the substitution of the modern high-pressure, high-speed steam engine for the heavy, slow-moving beam engine of the first half of the nineteenth century, we can begin to realize the transformation which will be made by the replacement of the existing reciprocating engine by the turbine with its high rotative speed, and in this way possibly we may rid ourselves of the limited idea of considering the steam turbine solely upon its own steam consumption.

MODERN GEODESY.

RECENT PRACTICE IN THE MEASUREMENT OF BASE-LINES AND ANGLES IN EXTENDED SURVEYING OPERATIONS.

Revue Générale des Sciences—Comptes Rendus.

FOR nearly two hundred years an important portion of the work of the engineer has been involved in the various attempts which have been made to measure the form and dimensions of the earth. The problem possesses an importance not only from the viewpoint of pure science, but lies at the bottom of all the practical work of surveying, navigation, and terrestrial physics; while the principles of geodesy must enter into all surveys of which the extent is sufficient to render it necessary to take the figure of the earth into account. For these reasons the report of the committee of the French Academy, having in charge the scientific control of the geodetic operations recently conducted at the equator, and published in *Comptes Rendus,* is of present interest and value. To this may be added the extended paper of Commandant Bourgeois, the officer in charge of this work, this latter article appearing in a recent issue of the *Revue Générale des Sciences.* Both articles are really due to Commandant Bourgeois, but the limited space permissible in the pages of the *Comptes Rendus,* renders the supplementary article the more complete.

Although much important work in the measurement of various arcs has been performed by independent investigators, including the determination of the meridian of France by Cassini, and the polar and equatorial measurements, made during the middle of the 18th century, and revised at the beginning of the 19th century by Borda, Delambre, Méchain, and Legendre in connection with the formation of the metric system, it was not until quite recently that the efforts of the International Geodetic Association have arranged the systematic exploitation of the surface of the earth by which different nations have underaken to contribute their share toward an accurate solution of the whole problem.

Thus, in the United States, two great chains of triangles have been measured, the one extending from the Atlantic to the Pacific, and the other from the northern to the southern boundaries. A general account of this latter line, along the 98th meridian of longitude, was given in our issue of October, 1902, where the methods of base measurement especially are discussed. The work which is now being undertaken by Great Britain, begun in 1899, for the measurement of the length of a meridian extending from Capetown to Alexandria, is another example of the extended scale upon which the matter is being developed; this arc, when completed, including about 65 degrees, of which 30 degrees will lie on each side of the equator.

Another valuable piece of geodetic work, recently completed, is the measurement of an arc of 4.5 degrees in length on the island of Spitzbergen, this being of especial importance because of its high latitude, lying between 76 and 80.5 north latitude. This work, which was undertaken by a joint commission sent out by Russia and Sweden, was fully described in our issue for March, 1903, and is interesting especially from the fact that the new nickel-steel

alloy of minimum expansion was used for the measuring tapes.

The expedition under the charge of Commandant Bourgeois has been engaged in the measurement of an arc of 6 degrees in length, this lying in the republic of Ecuador, in close proximity to the equator. This work was undertaken in accordance with the conclusions reached at the general conference of the International Geodetic Association held at Stuttgart in 1898; it being thought desirable to have a new set of measurements made upon the territory upon which Bouguer and La Condamine had made the first determination of an arc of the meridian near the equator in the 18th century. The actual work was begun in 1901, by an expedition of six officers and fifteen subordinates, their surveys extending from the Colombian frontier on the north, to the boundaries of Peru. For the details of this work reference must be made to the report of Commandant Bourgeois, but some review may here be made of the improvements on geodetic work described in his paper, to which reference has been made.

The most important element in geodetic surveying is naturally the measurement of the base lines, although it has been maintained, with some reason, that this element has received a disproportionate share of attention. The earlier base-line measurements were made with metallic bars, either compensated for variable expansion or provided with means for determining the temperatures and making subsequent corrections. The latest refinement in the bar method is that originated by the United States Coast and Geodetic Survey, using a single bar immersed in melting ice, the containing trough being carried on a suitable car upon a temporary track. This method, which undoubtedly eliminates all temperature error, is now employed mainly for testing the accuracy of the metallic tapes and wires used in the actual field work, and for this purpose it forms a valuable standard of reference.

The use of the bar in the field was displaced a number of years ago by the apparatus of Jäderin, in which the measurements are made with metallic wires under constant tension. The original Jäderin apparatus consisted of two wires, each 24 metres in length, one being of steel and the other of brass. These wires have short graduated scales attached to them at the ends, and in use are stretched by a weight of 10 kilogrammes, and supported by tripods. The two wires being of the same length at standard temperature, the difference between any simultaneous measurements made with them must be owing to their change of length due to the temperatures during the measurements, so that the wires themselves form a metallic thermometer indicating the summation of the variations in temperature during the work. This enables the temperature correction to be computed very accurately, while the length of the wires enabled the work of measurement to be conducted much more rapidly than with the old bar system. The discovery, by M. Guillaume, of the alloy of 64 per cent. of steel and 36 per cent. of nickel, this possessing an exceedingly low coefficient of expansion, has further simplified the process, a single wire of "invar," as the nickel-steel alloy has been named, replacing the two wires of the original apparatus. The measurements of the Spitzbergen survey were made with tapes of invar, and the accuracy of the results were fully verified, so that this method will doubtless become general.

The measurement of horizontal angles continues to be made in much the same manner as has obtained for twenty years past. The repeating circle, as constructed by Brünner, appears to represent the highest type of construction, but in France and in Germany the measurement of angles is often made by the method of Schreiber, all the angles being measured from each station in all the combinations which can possibly be made, these being used to check each other. The principal objection which can be made to this system lies in the fact that the illumination is not uniform in all direction, so that the various observations cannot all have the same critical value.

In addition to the horizontal measurements, both linear and angular, there are other determinations which fall within the province of geodetical survey, and these are also considered by Commandant Bourgeois. These investigations include the deviation of the vertical in various localities, the variations in the intensity of the force of

gravity, and various applications of the methods of precise levelling.

The measurement of the variations in the intensity of gravity by the method of Hecker is given attention, this method consisting in a comparison, for any given place, of the indications of the mercurial barometer and the hypsometer. The latter method measures the pressure of the atmosphere by the determination of the boiling point of water, and any difference shown between its indications and those of the mercurial barometer may be considered as due to a variation in the action of the force of gravity upon the mercury. Determinations of the force of gravity in the Andes by the present expedition show such a close accord with the results of Bouguer, made more than 150 years ago, as to reflect great credit upon the work of the earlier observer.

In general, the paper and report of Commandant Bourgeois, give an excellent view of the present state of the art of geodesy, including the latest progress made in the theory and practice of surveying in its highest branches.

LIQUID FUEL TESTS IN ITALY.

DATA AND RESULTS OF TRIALS WITH PETROLEUM IN COMMERCIAL MARINE SERVICE IN THE MEDITERRANEAN.

Rivista Marittima.

LIQUID fuel has been used for a number of years on the steamships plying on the Black Sea, and the results appear to have been altogether satisfactory. More recently trials have been made in America, especially in connection with the development of the oil fields of Texas, and the reports made to the Navy Department are well known. In a recent issue of the *Rivista Marittima* is given an account, by engineer Salvatore Orlando, of the tests recently made upon the Tebe, a vessel of the Navigazione Generale Italiana, on the service between Genoa and Alexandria, and the results are of sufficient interest to demand review.

The Tebe is equipped with a triple expansion engine of 2,000 indicated horse power, steam being furnished by two double-ended cylindrical boilers, Howden's system of forced draft being used, with a steam pressure of 12.66 kilogrammes (180 pounds), and the tubes being fitted with retarders.

The tests were made with Texas petroleum supplied from Alexandria, the oil having a specific gravity of 0.931 at 15° C. and 0.905 at 55° C. Upon test this oil began to give off gas at a temperature of 91° C., and ignited at 110° C. It contained 1 per cent. of sulphur, and gave a residue of 0.021 per cent.

The equipment of the furnaces is of interest, since it involved but trifling changes from the arrangement for coal firing. The grates were removed from the corrugated furnaces, and the latter were lined with refractory material for a length of about one metre, there being also a contracted mouth or ring of fire clay fitted to the entrance of the furnace. The spraying nozzles, of which two were fitted to each fire door, were of the Körting style, pulverizing the oil by means of steam jets, and the petroleum was supplied under pressure from Worthington feed pumps, the oil feed pipes passing through a heater before reaching the pulverizers, so that the temperature of the fuel was raised to 80° to 90° C., this enabling it to pass readily through the filters placed in the nozzles. The oil was stored in the double bottom of the ship, from which it was drawn and delivered to feed tanks as required.

The plant was installed under the requirement that it should give an evaporation of 13 kilogrammes of water per kilogramme of combustible, under a steam pressure of 12.66 kilogrammes, with feed water at a temperature of 70° C. During the trials, however, an evaporation of 13,200 kilogrammes of water per hour was obtained with a consumption of 958.4 kilogrammes of oil, corresponding to a rate of evaporation of 13.77 kilogrammes. During the tests the temperature of the feed water was only 36° C. instead of 70°, and correcting for the additional heat thus required, the result corresponds to an evaporation of 14.55 kilogrammes of water per kilogramme

of combustible, from 70° C. against a pressure of 12.66 kilogrammes.

These tests were supplemented by sea trials during the entire run from Genoa to Alexandria, the engines being run at full power, and the regular stops at Leghorn, Naples, and Messina being made. From the tabulated results given in the report the fuel consumption averaged 0.477 kilogrammes of petroleum per horse-power hour, or practically one pound per horse power; while the consumption of coal under identical conditions was never less than 0.68 kilogrammes, or about 1.5 pounds per horse power. Under both arrangements the air was supplied by the Howden apparatus, and the engine operated at about 11 expansions, at 84 revolutions per minute.

According to the report, the only difficulty which was experienced with the apparatus was the occasional obstruction of the filtering device forming a portion of the pulverizers. This obstruction appeared to consist, not so much of dirt in the petroleum, as of a carbonaceous deposit, probably formed by the action of the heat upon the oil. The formation of the deposit was indicated by the increased pressure necessary to deliver the oil to the burners, and it was found entirely practicable to clean the filter screens successively without interfering with the operation of the engines.

The results of these tests confirm fully the experience which has been had with liquid fuel in vessels elsewhere. No data are given as to the price of petroleum delivered at Alexandria, but so far as steaming value is concerned it appears to be fully confirmed that one pound of fuel oil is about equal to one-and-a-half pounds of good steam coal. In comparing costs the greater advantages in handling the oil should be considered, especially the difference between the convenient manipulation of the oil burners as compared with the laborious and brutalizing work of stoking coal furnaces at sea. The real question to be considered really appears to be that of fuel cost alone, and with definite data as to performance this element can readily be determined for any locality by comparing the relative local prices for coal and oil.

THE TESTING OF LOCOMOTIVES.

METHODS OF LABORATORY AND ROAD TESTS AND THEIR PRACTICAL APPLICATIONS TO DESIGN AND OPERATION.

W. F. M. Goss—American Society of Mechanical Engineers.

IT is now generally accepted that the true way to effect important improvements in any class of machinery is by means of careful scientific testing of existing machines, operated as nearly as possible under actual working conditions. The stationary steam engine is an excellent example of the development which results from an intelligent use of the results of careful testing, but in the case of the locomotive the conditions are not so favorable for the conduct of scientific trials. Road tests are made from time to time, but these are necessarily limited to the observation of such elements as can be measured while the machine is in motion. The actual resistance of grades, flange friction, and the like cannot be determined with that precision essential to accurate study, while the draw-bar pull, for example, requires a much closer determination than can be measured by any form of portable dynamometer.

In an important paper, presented before the joint meeting of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers, recently held at Chicago, Professor W. F. M. Goss, himself closely identified with the development of the accurate testing of locomotives, discussed the growth of locomotive testing plants, from the early experiments of Borodin, in Russia, to the latest installation, that of the Pennsylvania Railroad Company, at the St. Louis exposition, this latter now being operated in the work of making comparative tests of a number of standard types of engines.

The early trials of M. Borodin consisted in arranging a locomotive engine to be operated temporarily as a stationary engine, by blocking the driving wheels up clear of the track, and allowing the power to be absorbed by driving shop machinery. This permitted the performance of the boiler to

be studied, and also enabled indicator diagrams to be conveniently taken from the cylinders under conditions of determinate loading; and the work upon these tests, made in 1881 and 1882, demonstrated the economy of compounding and the advantages of jacketing.

Nearly ten years after the experiments of Borodin the first complete locomotive testing plant was erected at Purdue University, La Fayette, Indiana, under the supervision of Professor Goss, and from this plant, rebuilt after its destruction by fire, others have been developed, that at the St. Louis exposition being the latest and most complete.

"The Purdue plan for mounting a locomotive for experimental purposes involved supporting wheels carried by shafts running in fixed bearings, to receive the locomotive drivers and to turn with them; brakes which should have sufficient capacity to absorb continuously the maximum power of the locomotive, and which should be mounted on the shafts of the supporting wheels; and a traction dynamometer of such form as would serve to indicate the horizontal moving force and at the same time allow but a slight horizontal motion of the engine on the supporting wheels. Assume an engine, thus mounted, to be running in forward motion, the supporting wheels, the faces of which constitute the track, revolving freely in rolling contact with the drivers. The locomotive as a whole being at rest, the track under it (the tops of the supporting wheels) is forced to move backward. If now the supporting wheels be retarded in their motion, as, for example, by the action of friction brakes, the engine must as a result, tend to move off them. If they be stopped, the drivers must stop or slip. Whether the resistance to be overcome in turning the supporting wheels is great or small the force to overcome it is transmitted from the driver to the supporting wheel, and will reappear as a stress on the draw-bar, which alone holds the locomotive to its place upon the supporting wheels. The dynamometer constitutes the fixed point with which the draw-bar connects and serves to measure stresses transmitted. It is evident from these considerations that the tractive power of such a locomotive may be increased or diminished by simply varying the resistance against which the supporting wheels turn, and that the readings of the traction dynamometer will always serve as a basis for calculating work done at the draw-bar."

The friction brakes by which the power of the engine is absorbed are of the form designed by Professor Alden, consisting of a fixed case containing alternate fixed and moving discs, the case being filled with oil under pressure. The traction dynamometer, by means of which the draw-bar pull is measured, is based upon the principle of the Emery testing machine, this form being exceedingly sensitive and at the same time capable of resisting the tresses which are brought upon it.

"With reference to the results which have been obtained from the second Purdue plant during the ten years which have elapsed since its establishment in 1894, it is perhaps not too much to say that some of the facts concerning locomotive performance, which to-day are generally accepted, and hence quite commonplace, were first made known, or, if previously surmised, were confirmed by results obtained from this plant. The limitations affecting such simple factors as indicated horse-power and rates of combustion, are now commonly understood, but were much in doubt prior to the advent of the Purdue plant. It has shown that the American locomotive will, under favorable conditions, develop an indicated horse-power upon the consumption of from twenty-five to twenty-six pounds of steam per hour; a fact which ten years ago was accepted with expression of surprise. It has served to define the evaporative performance of the locomotive boiler. It has demonstrated, contrary to a belief once held, that steam delivered from the locomotive is practically dry. In the discussion concerning the advantage of controlling the output of power by means of the reverse-lever, rather than by the throttle, which was current ten years ago, a conspicuous part was given results obtained from the laboratory. It has shown that in a simple engine, the maximum cylinder performance results from a cut-off, which is between the limits of ½ and 1/3 stroke, and has demonstrated the whole relation of steam consumption to cut-off, under a considerable range of speeds.

Among the more specialized problems that were undertaken may be mentioned a study of the value of the steam pipes within the smoke-box when regarded as superheaters; the extent to which fuel loss is involved in the discharge of sparks from the stack, under different rates of combustion; the action of the steam-jet as a means of producing draught, and an investigation of the proportions which for maximum efficiency should be given the exhaust-pipes and stack."

As already indicated, the plant at the St. Louis exposition is identical in principle with that at Purdue, with the added refinements which have been developed in the 10 years of working experience. Especial facilities are provided for the reception of locomotives of various kinds, and the prompt adjustment of the operative parts to the variable conditions. Unusually complete devices for observing the results are provided; these including the accurate weighing of the coal and water, the recording of pressures, the observing of the quality of steam, of speeds, and of temperatures. An important feature of the tests is the provision of a staff sufficient to complete the computations for any engine, so that the results may be tabulated and available for comparison before the next run is made. This will enable the elements obtained for any engine to be kept in mind in the succeeding tests, and comparisons to be made during the runs.

In thus installing and operating a testing plant at an international exhibition, a single railway company may well be congratulated on having made a most valuable contribution to applied science, and in placing the supervision of the tests in the hands of such organizations as the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association, the results will be given an authority beyond question or cavil.

SANITARY CONDITIONS AT PANAMA.

PRESENT AND FUTURE HEALTH CONDITIONS ON THE ISTHMUS IN CONNECTION WITH THE CONSTRUCTION OF THE PANAMA CANAL.

Dr. W. C. Gorgas—Engineering Record.

IT is generally admitted that one of the most serious problems to be contended with in the construction of the Panama canal is that of maintaining proper health conditions. During the construction of the Panama railroad and later at the time of the work of the French upon the canal, the losses by disease were very great, but there is every reason to believe that if the operative conditions are attacked in the light of modern science, the losses may be maintained at a minimum upon the new work now to be undertaken. For this reason the report of Dr. W. C. Gorgas, himself noted for the success with which he combated the malaria and yellow fever at Havana, is especially noteworthy. Dr. Gorgas went to Panama with the Isthmian Canal Commission, and his report to Admiral Walker has been published in a recent issue of the *Engineering Record*, from which we make some abstract and review.

"The Isthmus runs in a general direction from east to west, and the canal route generally from north to south. The town of Colon is the northern terminus of the canal, on the Caribbean Sea, and the town of Panama, the southern terminus, on the Pacific Ocean. The great chain of mountains which extends through North, Central and South America, has at this point, about its least elevation, the highest point of the divide through which the canal runs being here about 500 feet. The country is generally volcanic in its formation, thickly studded with numerous peaks and ridges, from 300 to 800 feet high, and should be described as being very hilly, and well drained.

"The canal, in general, follows the line of the Chagres river up to the divide at Culebra Cut, some ten or twelve miles from Panama, and from Culebra down to Panama, the valley of the Rio Grande river. These streams are not swampy in any sense of the term. The rivers mentioned above, of course, have a certain amount of low ground in their bottoms, but not more than a stream of the same size in northern New York. Owing to the warm climate and heavy rainfall, mosquitoes can find, all the year round, abund-

ant places for breeding, even in as well-drained a section as the route of the Panama canal is.

"Colon is built upon a coral island in Limon Bay, the island itself being slightly below the main level of the sea. The part of this island on which Colon is situated is artificial ground, having been filled in three or four feet. The rest of the island is still covered with swamp. This is the only point at which swamps of any great extent would have to be dealt with."

Dr. Gorgas states that he considers the canal strip in the normal state for tropical regions, from a health point of view. That is to say, the death rate would be about fifty per thousand, very high for northern climates, but not excessive for the tropics. At the present time there are about 40,000 persons on the strip, there being 20,000 at Panama, 3,000 at Colon, and 15,000 in the little towns along the route. If we gain our ideas from the death records during the construction of the Panama railroad or the French work on the canal, we must consider the locality as most unhealthful. If, however, we view the question in the light of modern knowledge and methods, we may see good reason for a modification of this view.

According to Dr. Gorgas, the principal disease to be overcome is malaria. There is a certain amount of yellow fever, which may be eliminated by the same methods which have proved successful at Havana, but the chief danger is from malaria, and if the malaria is not controlled the mortality will be very great.

According to the investigations of Dr. Gorgas, the chief danger from malaria lies in the infection of the unacclimated white men from the malarial natives through the mosquito. Nearly all the negro inhabitants of the local villages are victims of chronic malarial infection, and the presence of the poison-bearing mosquito, or anopheles, renders it practically certain that the imported laborers will be infected, if some means are not taken to prevent it. Such preventive measures are entirely possible, as Dr. Gorgas shows:

"What I propose, is to take each village, put it under a systematic scheme of inspection whereby we shall be able to control all water barrels and deposits of water, so that no mosquitoes will be allowed to breed, look after its street cleaning and disposal of night soil, etc., so as to get it in good sanitary condition, then have the population examined and recorded, so that we shall have on a card a short history of each individual, and keep track of them in this way. Those suffering from malaria will be put under treatment, and watched as long as the malarial parasite is found in the blood. I hope, in this way, to decrease to the smallest limit the number of anopheles, the malarial-bearing mosquito, and, at the same time, to gradually eliminate the human being as a source of infection, so that at the end of a year it will be entirely safe for an unacclimated man to live in any village."

So far as yellow fever is concerned, its prevention will depend principally upon the sanitary work which is done at Colon and at Panama, and the quarantine arrangements for preventing its introduction. This problem is not greatly different from that at Havana, and there should be no difficulty about carrying these out on both sides of the Isthmus.

Dr. Gorgas speaks plainly about the extreme views on both sides which are heard upon this important subject, as he says:

"I hear two opinions expressed with regard to the health of Panama. The general opinion, that one sees in the papers, is that it is almost fatal to live there, people expressing this opinion thinking that the conditions there now are exactly the same as when the French had fifteen or twenty thousand laborers on the work, and were losing by death and sickness a considerable proportion of this force every year. This is, of course, not true. The health conditions of Panama, at present, are not a bit worse than those of most other tropical countries. On the other hand, particularly down at Panama, you hear men talk as if it were a health resort. This is not so. The death rate now is large, as I said before, about like that of most tropical countries, and unless we can change conditions within the next year it will be far from a health resort, when our large force of laborers are on the ground and the work is in full swing. I recently saw an engineer, who had been on the ground for some time and was a man of considerable experience, quoted as saying that both the engineering and sanitary problems were simple and could be easily solved.

Of the engineering problems I am no judge, but such statements with regard to the sanitary problems, by men of position and experience, I think are very rash and tend to do harm. In my opinion, the sanitary problems are grave. The question of eliminating yellow fever from an endemic focus has only been once before successfully managed, and that was to Havana. And, from this successful work, to argue that it is easy and simple, I think is not warranted. The malarial work, on the scale at Panama, is entirely new. It has never been attempted elsewhere, and any health officer, who has had any experience in enforcing measures of individual prophylaxis, such as will be required at Panama, can understand how great the difficulties of administration will be. Personally, I believe it can be done, and I approach the work with great hope of success, but I know that it will be neither easy nor simple, that we will meet with many disappointments and have to modify our plans many times."

THE IRON AND STEEL INDUSTRIES OF THE WORLD.

A STUDY OF THE STATISTICS OF MANUFACTURE, EXPORTS, AND IMPORTS IN CONNECTION WITH THE INDUSTRIAL POSITION OF GREAT BRITAIN.

William Pollard Digby—Society of Arts.

WHATEVER may be the outcome of the present agitation in Great Britain with regard to the much discussed fiscal question, there is no doubt that it has been, and will doubtless continue to be the cause of the study of a number of most important elements which go to make up the manufactures and commerce of the Empire. Among such investigations we may note an important paper examining the statistics of the iron and steel industries of the world, recently presented by Mr. William Pollard Digby before the Society of Arts, and published in the *Journal* of the society.

Mr. Digby examines the subject from three separate points: that of the supplies of ore and the production of pig iron in the United Kingdom, as compared with Germany and with the United States; that of the relations of the import and export trade of Great Britain to the external trade of other countries; and that of the margin of profit of the iron industries reckoned on the external trade alone of the leading iron-producing countries.

"A complete survey of so vast an undertaking as the British iron trade, with its many ramifications, its complex questions, might well appal a Royal Commission, while an extension of the survey to the dissection of the exact situation in regard to every branch of the iron and steel industries of the United States and Germany would occupy a special International Commission for an indefinite period.

"The difficulty likewise hinges upon the question of internal consumption, of what proportion the home market bears in each case to the country's export trade, and as to how far the imports from other countries affect the home market. The relation of the import and export trades to each other is easily defined, and the chief sections of the import and export trade receive separate enumeration in the various Government returns. While it is possible to define the value, say, of steel rails, respectively imported and exported from the United Kingdom, we do not know the total production of the value of steel rails used in any year by the different railway companies and tramway undertakings within the kingdom. Again, it is possible to give the value in any year of the locomotives sent to foreign countries and to our own Colonies, and it is not difficult to enumerate the sporadic dumpings of locomotives into England on those occasions when lack of foresight had allowed the number of engines under construction to fall below immediate requirements, so that occasional purchases from America resulted. We can, in this latter case, go a step further and give the number of locomotives included in the rolling stock for any one year. But we cannot give the amount of the expenditure in any year on new locomotives either for our railways or for the rough lines laid by contractors for their dock, or reservoir, or railway, constructional work.

"Similarly, if we regard shipping, while

returns have of recent years been published giving the values of our sales of new ships built for foreign countries, we have no return of the value of the yearly additions to our mercantile marine, or of the value of the plates, rivets, or stern-frames which, forming the raw material for the shipyard, are nevertheless the finished product of the steel merchant. We are also without returns as to the value of the iron and steel supplied to the ship's engine builders wherein 'the purring dynamos,' the towering five-crank reciprocating engines, the compact turbines, the belauded Scotch and belittled Belleville boilers, find their raw material.

"Turning to the textile of electric cable factories of Lancashire of the paper mills of Thames valley, no returns tell of the proportion of foreign machinery therein installed or of the extent to which the manufacturers of their myriad engines, boilers, looms, brading machines, potchers, shafting, or pulleys, have indented directly on foreign or on British machine makers, or have purchased high-class machinery, itself in part made from raw iron or raw steel produced, perchance, in a foreign country."

Taking up first the question of the production of iron ore and pig iron, the statistics of Great Britain, Germany, and the United States are shown by curves covering the past thirty years. Broadly these show a gradual fall in British production of ore as against an increasing British consumption. Both Germany and the United States have been developing their own local deposits, although both England and Germany are obliged to look abroad for the raw material for their furnaces. It is this question of the necessity of importing iron ore which has, in the minds of many, placed Great Britain at a great disadvantage, but Mr. Digby calls attention to the fact that the inflow of ore, essential to the existence of British iron furnaces, supplies also income on British investments.

"Ore beds in northern Spain have been purchased, railways built, and machinery supplied. Steamship services have been organized, blast furnaces erected on the seaboard, so that in some cases the ore is carried with only two handlings from the ship's hold to the furnace mouth. Those who talk loudly of the extinction of the iron industry have not recked of the manner in which the iron industry has called, not in vain, on the country's capital to provide other sources of raw material."

In this respect the position of England is not unlike that of the Pittsburg district in the United States; the supply of ore brought by the lake steamers having developed the iron-making industry on the shores of the Great Lakes. There is this difference, however, that in the United States the supply of ore may and does lie in other States of the Union, but not without the boundaries of the nation, or in another country.

Taking up the question of the export and import trade of the several countries, some interesting features are brought out. These also are plotted in diagrams, showing that, while British export trade has suffered fluctuations, it has, on the whole, exhibited a steady rise, and furthermore, has shown a corresponding proportion of profit. It is with the margin of profit between exports and imports with which Mr. Digby concerns himself, and in this respect he takes an interesting view of the question, computing the relative value of the profit measured in food. For this purpose he makes use of Sauerbeck's index values for food for the corresponding periods. Upon this basis it appears that the maximum of profit was not in the early seventies, the era which has been so often cited as the zenith of free trade prosperity, but between 1888 and 1892. It may be advanced that while the coefficient of food profit has advanced the population of the country has advanced at an even greater rate. This, however, is considered by taking the profits per head of population, which has some interesting features.

Mr. Digby takes the period from 1868 to 1902, divided into quinquennial periods, and from his figures it appears that during that period the profits per head of population have fallen off to about one-half that which obtained at the beginning. At the same time the profit margin per head of population in the United Kingdom still stands at about threefold that recorded for either the United States or Germany. These latter countries, however, show an increasing rate, the United States a rapid one, Germany more slowly.

A strong plea is made by Mr. Digby for

more complete statistics of internal trade.

"Whether our studies of industrial economics will on one hand continue to be as full and as complete as the wit of man and the Board of Trade returns can make them, or on the other hand be limited to surmises based on the condition of the external trade (simply and solely because we have no records of the quantities and values of our manufactures which are internally consumed) rests with the manufacturers of this country. Any person can prate of exports and imports, but who can speak even in regard to iron, of the employment given to thousands of artisans making looms for Lancashire, locomotives and rails for our railways, dynamos and arc lamps for our street lighting, steel girders and angle iron for our large buildings? Or, again, as regards the value of the shipping added each year to our mercantile marine; while it would not pass the wit of Dr. Ginsburg to estimate the capitalised value of the shipping on Lloyd's Register, even he might fight shy of estimating the apportionment of the expenditure of a single year's increase among the many industries whose concerted efforts have fed the ship builder. Yet large quantities of our food imports are paid for by new ships made to foreign order, other quantities of food are paid for by old ships sold for a few more years of life or to be broken up, while still other quantities of the imports which enter the country are the earnings of ships carrying the red ensign and launched in the preceding year.

"A great volume of our iron must surely go into what, for varying reasons, are investments which are directly or indirectly remunerative, railways, shipping, locomotives, lathes, looms, or other machinery; even the hammer and cold chisel are not unproductive directions either for home manufactures or imports.

"'Among the blind, the one-eyed is King.' What shall we say of John Bull, who is not even equipped with half his powers of vision when considering his own entire commerce? External commerce is clearly displayed in export and import returns. Internal commerce is practically shut off from his vision. Its fruits, so far as percentage of pauperism or saving banks returns are concerned, can be gauged any day. But the full extent of the effects of 'dumping' can only be truly known when manufacturers will consent to a dissection of the statistics, not only of the trade of manufacturer A whose finished article is threatened by foreign competition, but also by a dissection of the trade of manufacturer B whose raw material is often the finished product of manufacturer A.

"At a time when ill-digested statistics are thrown to and fro in argument, a plea for more statistics sounds impertinent. Yet some measure of the relation of imports not alone to exports, but to home consumption also, is surely necessary before we talk of doomed industries. Will none cease from a strife of the rival panaceas—protection, altered business methods, temperance, retaliation, education, free labour, bounties, and so forth (good though some of these may be) and unite to obtain the true figures of internal trade and its relation to exports and imports? For, only when these have been obtained are the component parts available with which alone it is possible to paint the only veracious picture of the nation's true condition."

HIGH-SPEED STEAM LOCOMOTIVES.

DESIGNS FOR STEAM LOCOMOTIVES FOR COMPETITION AGAINST HIGH-SPEED ELECTRIC TRACTION.

Glasers Annalen für Gewerbe und Bauwesen.

As a result of the high speeds attained by the electric cars on the Marienfelde-Zossen military railway the locomotive builders of Germany have become aroused, and in consequence the *Verein Deutscher Maschinen Ingenieure* arranged a competition for the best designs for high-speed steam locomotives. From among the plans submitted there have been five selected as superior to all the others and in a recent issue of *Glasers Annalen* these designs are compared by Herr W. Wolters, the several locomotives being fully shown by drawings. These engines have been de-

signed for continuous running speeds of 120 to 150 kilometres per hour, or 74.6 to 93.2 miles per hour.

It is impracticable to give in this place any complete description of the several designs which have been thought worthy of award in this competition, but some general examination of the elements which have been assumed by the designers to be essential in producing a high-speed machine may prove interesting.

In the first place compounding has been adopted by all the competitors, four out of the five machines being of the four-cylinder balanced variety, and the fifth having three cylinders. This latter machine is peculiar in that it has the three cylinders of the same diameter, the single inside cylinder being the high-pressure one, this exhausting to the two outside cylinders, giving a ratio of two to one. In the case of the four-cylinder compounds the ratio ranges from 2.4 to 3 to 1. In weight the engines range from 75 to 95 tons, the power running from 1,000 to about 1,350 horse power. With but one exception the engines are intended to be operated at a boiler pressure of 14 metric atmospheres, or 200 pounds per square inch, one of the four-cylinder compounds being planned for 15 atmospheres, or about 227 pounds per square inch pressure.

The general inspection of the plans shows that the various designers have attempted to insure a sufficient supply of steam by using it with the highest economy. Thus three of the designs include superheaters, while the two remaining machines have a greater amount of heating surface in the boilers, doubtless to provide a necessary additional steaming power. Nearly all the plans appear to have made some attempt at minimizing the wind resistance by encasing the entire machine in a casing with wedge-shaped prow and smooth sides and top, although it is probable that this plan offers a greater area for the action of lateral wind pressures in crowding the flanges against the rails, than with the ordinary uncased machine.

One of the most interesting features about the various competing designs appears in the efforts which have been made to reverse the usual arrangement of things and place the engineer in the front of the whole machine, thus giving him the same advantage as regards position as is occupied by the motorman of an electric car. There is no real reason why a locomotive should ever have been arranged to run with the smoke stack in front, and the engineer craning his neck around to obtain a view of the track, and it is a matter for surprise that designers should have waited as long as they have to place things in their correct position. Some of the engines submitted in the competition show a reluctance on the part of their designers to remove the smoke stack from its time-honored place in front, and place the engineer in the front of the machine and the fireman behind, thus separating two men who should be always in close relation to each other. Herr Richard Avenmarg, of Munich, alone has the courage of his convictions, and boldly turns the whole machine around and places the engineer and fireman in a commodious cab in the very front of the engine, and relegates the smoke stack to the rear, thus giving an uninterrupted view of the track, free from smoke and cinders, regardless of the opinions of more conservative members of the fraternity.

Since these various designs exist at present entirely upon paper, it is too soon to pass upon their merits in detail; it will be time enough for that when they have been built and given actual trial. At the same time the speeds which they are expected to attain are not higher than have been successfully reached by locomotives of existing designs, so that even if they succeed in attaining the ends of their designers they will have performed nothing very notable. Indeed, it has been realized for some time that the present limit to locomotive speed is not that of engine construction, but rather that of the provision of solid, rectilinear, uninterrupted roadway. After the track shall have been made perfectly ready, with perfect alignment, and massive rails, and existing forms of locomotives shall have shown their inability to make the speeds which this competition demands, it will be ample time for builders to exert themselves to produce new designs, which will themselves, in turn, demand still further improvements in the track upon which they are to run.

MODERN STEAM ENGINE TESTING.

THE EQUIPMENT, OPERATION, AND IMPORTANCE OF THE TEST HOUSE OF A MODERN ENGINE WORKS.

R. K. Morcom—Institution of Electrical Engineers.

NOT so very many years ago the subject of testing steam engines was considered to be a matter entirely within the province of the specialist, and when a test was to be made the consulting engineer and his staff appeared in the room where the machine was already installed and went through the elaborate performance with the aid of such portable appliances as they could bring with them.

Such tests are even now made upon large engines, especially if the determination of the fulfilment of certain contract requirements must be made, but there is another side to the subject of steam-engine testing, about which not so much has been written, and concerning which an interesting paper has been presented before the Birmingham Local Section of the Institution of Electrical Engineers by Mr. R. K. Morcom. This portion of engine testing relates to the critical trials to which engines are subjected by their builders before delivery to the purchaser, such trials usually being conducted in a special test house constructed for the purpose. Mr. Morcom's paper discusses mainly the equipment of such a test house, and the practical methods of operation. As he well says:

"The days of broad guarantees of coal consumption of a plant per month or per annum have now passed, and the era of the specialized testing has been inaugurated by modern competition. Nowadays boilers, engines, generators, and motors must all be proved to fulfill the specification as to efficiency and reliability, and it is on the closeness with which the results obtained approach the guaranteed figures that the justification of an enterprise often depends.

"The value of the experience gained by tests is so great that all progressive manufacturers lay down more or less extensive testing plants for their own use, and so it is only natural that their test houses should also be used to demonstrate guarantees, and so insure that time shall not be wasted on site, and to avoid the inconvenience to a station engineer of having his station turned into an experimental testing department."

The plant described by Mr. Morcom is intended to receive units ranging in size from 75 to 1,250 horse-power, running either condensing or non-condensing, with steam pressures from 80 to 250 pounds per square inch, and from saturation up to 350° F. superheat.

The electrical requirements include currents from 10 to 2,000 amperes with voltages from 60 to 6,000, either continuous or alternating, of various frequencies.

Such a plant demands a high degree of flexibility, especially as the elements to be measured include temperatures, pressures, volumes of steam, water and air, mechanical and electrical energy, fuel composition and calorific value, gas analysis, etc. Facilities must also be provided for the investigation of the performance of mechanical details, such as the action of governors, lubricators, packings, gauges, and the like, so that the judgment with which the whole is arranged must have an important influence upon the convenience of operation. The detailed arrangement of the particular plant described by Mr. Morcom is therefore not of so much importance as an examination of its elements, since every such installation must be arranged to meet the especial conditions involved.

Steam should be provided by several independent boilers, so that tests at different pressures may be conducted simultaneously; pressure-reducing valves not having been found satisfactory. A separately-fired superheater is desirable, as giving greater control over the conditions of superheat, and facilities for weighing coal, measuring feed water, and drawing off reliable samples of flue gases for analysis, should be provided. All pipes should be lagged, and it has been found that asbestos rope of large diameter forms a convenient material for covering temporary pipe connections.

The use of mercury cups, inserted into pipes to enable thermometers to be employed in taking temperatures, has been found to lead to errors. The mercury-

pressure pyrometer has been tried, this instrument operating by the pressure of expanding mercury acting against a steel spring, and indicating upon a dial face with a needle. Mr. Morcom states that he has obtained satisfactory results by using a thin steel tube, screwed well into the steam pipe through a stuffing box, so that an asbestos packing may insulate it from the steam pipe, oil being used in the pipe instead of mercury as being more accurate and less liable to boil away at high temperatures.

Provision should be made for the reception and condensation of the entire exhaust steam from an engine under test, this providing the most accurate method of determining the steam consumption, and also being necessary for the operation of condensing engines. In the plant described by Mr. Morcom there are three surface condensers, so arranged as to be connected up as may be required, there being also an atmospheric exhaust main. The air pump discharge can be delivered into tanks attached to balances with electric annunciators, and every facility provided for the detection of leakages.

The loads placed upon engines under tests may be either mechanical or electrical, and when no dynamo is available power-absorbing brakes of the Heenan and Froude type may be used to advantage. Especial facilities for using the indicator upon the engines should be provided, and for machines with high rotative speed great care is demanded, both as to the accuracy of the instruments and to the methods of their connection, to insure reliable results.

The selection of electrical instruments must naturally depend upon the nature of the machines to which they are to be applied, and not a little also upon the predilections of the observer. There a number of standard makes which are acceptable to the profession, and these and the switchboard may readily be arranged so as to correspond closely to the actual equipment of a working station.

Since the resistances by which the electric current is absorbed form an important portion of a testing plant, the experience of Mr. Morcom in this respect may be found of value.

"After considerable trouble and expense in connection with wire resistances, both in wooden and iron frames, a form of water resistance for taking up the load has been devised. The poles are of iron, arranged in wooden tanks. Water from a neighboring canal is passed continually through the tanks by a by-pass on the condenser circulating pump, and flows out over a weir. The poles are connected to a load-adjusting switchboard, and can be coupled into the load in many combinations. Three tanks are used for different ranges of voltages, and these ranges are further divided by adjustments of the outflow from the tank. Specially subdivided tanks are used for polyphase work.

"The first experience when using a water resistance was not very satisfactory. The apparatus consisted of an iron tank about 3 ft. wide and 6 ft. long, with two large iron plates for the electrodes. This tank did not last very long, for the current, as well as passing from plate to plate, found a shorter passage by way of the sides and bottom of the tank. An improvement of this arrangement was a large wooden tank, 4 ft. wide by 10 ft. long, and about 4 ft. deep. Into this were fitted four hollow cone-shape castings, large end upwards. Inside each of these cones was a smaller one, suspended from above on a screwed spindle and hand-wheel. The outer cone was coupled to one terminal of the dynamo on test, and the inner through a flexible lead to the other terminal. Load could then be varied by raising or lowering the inner cone on the screwed spindle. It was necessary to keep the water-level a little higher than the top edge of the outer cone, so that the heated water in the space between the cones might rise naturally and flow away. This arrangement gave very satisfactory results; in fact, some cones are still in use which were fitted about eighteen months ago.

"For higher voltages it was proposed to use a metal rod dipping into the water at the centre of the cone; but the conducting area of water to the outer cone was too large, and the length of water resistance too small, for many machines. Accordingly, a wooden trough of small cross-section and great length was designed for high-voltage work.

"The use of wooden troughs did away with the need for conical poles, and it is

now found more useful to substitute iron plates fixed at the top to flexible terminals, and movable on insulated rollers along wooden runners. The load can thus be varied by sliding the plates along so that the cross-section between them is varied. By using a considerable number of small plates a very flexible load is obtained, and if care be taken with the circulating arrangements, a very steady load results."

The conduct of the work of such a test house demands experience and reliability, and the plant should be placed in the hands of an able and interested chief, with such assistance as he may deem necessary. It should not be regarded as a sort of scientific luxury, but rather as the completing process in the construction of both engine and dynamo, since such tests are principally made upon direct-connected generating sets. With such a department the manufacturer obtains a positive knowledge of the character of his work which gives him a confidence not otherwise attainable, while in many cases information is obtained which leads to important improvements.

"A testing-department is always accumulating results, and every result is entered up in careful history books, anomalous figures are remarked on, and, if possible, explained, and curves illustrating various points are frequently made. This mass of information is necessarily largely unpublished, and the public only hear of the work of those numerous well-equipped laboratories when some improvement is put before them in a fully-fledged condition. Probably much of the information is not used in the full, and doubtless there are many experiments made in engineering colleges and institutions to elucidate mysteries, when all the time the solution is lying clear to see in some manufacturer's record book."

THE RESISTANCE OF METALS TO CUTTING.

DYNAMOMETRIC MEASUREMENTS OF THE FORCES INVOLVED IN THE CUTTING OF METALS IN THE LATHE.

Dr. J. T. Nicolson—Institution of Mechanical Engineers.

SEVERAL months ago we reviewed in these columns the exhaustive experiments conducted by Dr. Nicolson at Manchester upon the performance of rapid-cutting tools steels, and now we have, in a paper presented at the Chicago meeting of the Institution of Mechanical Engineers an interesting account of the ingenious form of lathe-tool dynamometer designed and used by him in investigating the forces acting upon a cutting tool.

The object of such an apparatus will at once appear from Dr. Nicolson's account of the conditions which led to its design.

"In the tool-steel trials made by the Manchester Committee in 1902-3 (the report upon which was published by the Manchester Association of Engineers in their Transactions for 1903), there appeared an entire lack of uniformity in the shapes and angles of the tools submitted by the eight competing firms. There was also no obvious connection between the shapes and angles of the tools and the cutting forces upon these tools deduced in the report from the electrical power measurements made by the Committee. Neither did the shape or angle supply a clue to the causes of success and failure in the various trials with different tools.

"On the other hand, the necessary reconsideration of the design of lathes for the rapid and heavy cutting rendered possible by the new steels introduced by Taylor and White, and now everywhere adopted, calls for a thorough and systematic investigation of the forces acting upon a cutting tool. If a standard area of cut can be agreed upon for the various sizes of lathe, a knowledge of the forces to be overcome when taking that cut,—not only for turning the work against the tool, but also for moving the slide-rest and saddle in both the traversing and surfacing directions—will enable the calculation of the stresses in, and the proportioning of, the various parts of the machine to be gone about in a rational and scientific way.

"No such knowledge has hitherto been available; and it appeared to the author that the prosecution of a somewhat extensive research into the matter would well

repay the time, labour, and expense, which it would necessarily involve."

In reviewing the work of previous experimenters in this field Dr. Nicolson refers to the work of Hartig, who enunciated the law that the cutting force varies in simple proportion to the depth of the shaving; also to the investigations of Mr. Mallock, in the engineering workshop at Cambridge University. The experiments of Professor R. H. Smith are also briefly discussed, and the defective features of his apparatus pointed out. No mention is made, however, of the exhaustive researches of M. Codron upon all kinds of cutting operations, although these have been published in full in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale.* The researches of Codron, however, do not include the new high-speed steels, and so are of comparative value only, although they have thrown much light upon the true nature of all metal-cutting operations.

The detailed construction of the dynamometer of Professor Nicolson is fully given in his paper. In general it consists of an attachment to the tool holder and the slide rest, composed of hydraulic supports connected to Bourdon pressure gauges. The first form of dynamometer was arranged to measure only the vertical forces acting upon the point of the tool, while the second apparatus was constructed to measure not only the vertically directed force, but also that tending to push the tool and saddle backwards, and that tending to oppose the traversing feed. The apparatus was designed to permit pressure as high as 15 tons to be observed, and pressure of 10 tons were actually measured during the trials.

In conducting the tests it was necessary to assume certain trial forms and angles of tools. The first trials were made with tools having the cutting edge horizontal, and at an angle in plan of 45° with the axis of the work. The top surface of the tool was a plane containing the cutting edge, and inclined at the angle called "the cutting angle" to the vertical plane, which also contained the cutting edge. The cutting edge terminated at a point ⅜ inch from the right-hand corner of the tool (in 1¼ inch square tools) so that the average cut taken would give a downward thrust, acting as nearly as could be arranged in the centre line of the tool, so as to prevent any twisting action and undue load upon the steel centre points. The nose of the tool had a clearance angle in plan of not less than 1°, and a small radius was ground on the corner between the two edges. The front clearance was 6°, the tools being used with the cutting edge on the level of the centre of the work.

Tests were made upon case iron and upon steel with this form of tool, and also with tools set to the angles of 60°, 75°, and 90°, with feeds of 1/16, ⅛, ¼, and ⅜ inch, and with depths of cut of ⅛, ¼, ⅜, and ½ inch, the results being fully tabulated in the paper. Broadly the conclusions drawn are: for a given traverse the cutting force is simply proportional to the depth of cut; the cutting stress being constant for a given width of traverse and given tool angle. The cutting stress varied widely with the cutting angle, being a minimum for an angle of about 60°, although this is not the angle of greatest durability. A cutting angle of 80° appears to be the best adapted for shop use, the cutting stress for this angle being about 75 tons per square inch. The variation of cutting stress with traverse is somewhat complicated. For keen cutting angles, below 75°, fine traverses require less cutting force than wide ones, while for blunt-nose tools the reverse is the case.

In general it appears that the ordinary shop tool, when cutting soft steel, exerts a vertical force of about 100 tons per square inch of area of cut removed, irrespective of the proportion of width of traverse to depth of cut.

"All the trials were made in the endeavour to determine the laws of the variation of *cutting force* with tool-angle and with shape of cut. It was, however, not *à priori* to be expected that the tool-angle which gave the smallest cutting force would also prove the most durable or remove the greatest weight of material before failure. As this is a point of even greater practical importance than the other, two further series of trials were projected, one on the soft steel, the other with the medium cast iron, for the purpose of finding the cutting angle to be commended for shop use.

"In the cast-iron series a cutting speed of 44 feet per minute, with a cut 3/16 inch deep by 1/16 inch traverse, was decided upon,

after about fifteen preliminary trials had been made. It was found in these preliminary experiments that a foot per minute, more or less, in the cutting speed made a great difference in the duration of the experiment; and, as time and material had to be economised, the careful adjustment of the speed was necessary to ensure uniform and consistent results. Cutting angles of less than 60° were excluded, but it was decided to use tools of 60°, 65°, 70°, 75°, 80°, 85° and 90° cutting angles, and to run them at the above speed *exactly* until they failed."

The results of these endurance tests showed that for maximum endurance in cutting cast iron the tool should be ground so that the true cutting angle is about 81°; or if an angle of 6° for clearance be allowed, there will be an included angle of 75°. For steel a cutting angle of about 70° or an included angle of 65° appeared to last the longest for rapid cutting.

For the details of these and a number of other tests the reader must be referred to the original paper, but these general conclusions will be of special interest. The whole investigation leads to a confirmation of the points now being generally made in modern works management, and discussed in the articles by Mr. Ashford and Mr. Day elsewhere in this issue; namely, that the choice of the form and position of the tools should not be left to the unaided judgment of the workman, but should be determined according to scientific principles and experiment, and prepared by special mechanics in the tool room, leaving the duty of the machinist at the lathe, planer, or other machine to the use of the tools which have thus been prepared for him.

The importance of the experiments of Dr. Nicolson to the designer of machine tools need not be emphasised, since it is evident that they furnish him with data hitherto entirely lacking.

FIRES ON SHIPBOARD.

CONSTRUCTIONAL SAFEGUARDS AND METHODS OF FIRE PREVENTION AND EXTINCTION ON BOARD SHIP.

E. O. Sachs—Institution of Naval Architecture.

IN view of the recent disasters on vessels in various parts of the world the paper of Mr. Edwin O. Sachs, upon the prevention of fires on shipboard, presented before the Institution of Naval Architects is most important and timely. Mr. Sachs truly says that the subject has by no means received the attention which it demands, and in this respect there are few who will disagree with him, and those few will doubtless be those who permit their financial interests to overpower their better instincts of humanity and justice.

Since his experience has been almost altogether upon land, Mr. Sachs states that he considers a ship much as he would upon a building, but it must not be forgotten that a vessel at sea is much further removed from external aid than a building in a city. At the same time anything which will help to insist that all vessels shall be made practically fireproof demands consideration.

"In respect to the safeguards that call for consideration in these three classes of tonnage, they may be divided—as on shore—into (*a*) constructional safeguards, (*b*) safeguards in equipment, (*c*) administrative safeguards, and (*d*) safeguards in fire extinguishing. All these forms of safeguard should be applied to our shipping, each class of safeguard varying in importance for the individual class of tonnage.

"Regarding the constructional safeguards, the primary safeguard in design may be considered to be the one which is now being generally adopted on land, namely, that of dividing the ship into a maximum number of fire-resisting compartments, and this division, for the purpose of reducing possible fire risks, must be more extensive than that of the compartment system already in general use for the purpose of dividing the ship into water-tight compartments. It will be found easier to divide the ship into fire compartments that may be deemed individual fire risks, rather than into the water-tight compartments generally associated with shipbuilding designs. The divisional lines of the water-tight compartments will necessarily serve as a basis for the fire-re-

sisting compartments, but the latter should be more numerous. The horizontal division of a fire-resisting character does not bring with it any technical difficulties. The subdivision of the hold into smaller compartments than the subdivisions we generally know of is of little difficulty and inconvenience to the majority of cases. Having special regard to the passenger boat, there is not the slightest reason why the long flights of cabins and saloons should not have a more frequent subdivision than what is usually found in the subdivisions by water-tight doors. The primary safeguard against spread of fire in all ships of all classes will be their division into the largest number of small fire risks practicable with the work of the ship; and this number can and should far exceed the number of divisions made in order to obtain water-tight compartments.

Turning next to the safeguards in the application of materials in the construction of vessels, I consider the reduction of combustible material to a practical minimum to be an essential. For the passenger ship, however, in particular, the reduction of the combustible material should be compulsory; and, above all, the vast quantities of highly inflammable wood partitioning and fitments used on board our ocean greyhounds should be absolutely condemned. There is not the slightest reason why wood should be used at all to the extent it is at present, for with metal framing and the various forms of non-conductive sheeting of a non-inflammable character, the component parts of which are, to a considerable extent, asbestos, a very considerable amount of the woodwork could, *ipso facto,* be banished, to the advantage of all concerned; for these sheetings economise space, and are excellent non-conductors where climatic changes are encountered."

Mr. Sachs discusses at length the use of wood which has been rendered non-inflammable by chemical treatment, and maintains that he is of opinion that the non-inflammability of wood is a matter which has been solved commercially.

"Regarding safeguards and equipment, the two forms of equipment in respect to which a great deal more attention should be paid are the protection of the hot steam piping and careful electric wiring.

"Regarding the hot steam pipe, its protection in many instances is quite insufficient, particularly on the cheaper class of boat—*i. e.,* the minor passenger boat and the minor cargo boat. The result is that the hot steam pipe is frequently the cause of outbreaks of fire, afterwards attributed to spontaneous combustion or climatic conditions. The steam pipe should have additional protective covering beyond its ordinary isolation covering, in the form of a wire guard in all exposed places, so that anything lying right up against it does not touch the pipe or pipe coating—*i. e.,* there is an air space intervening."

The electrical risk is mainly one of neglect and might be made a minor matter by the insistence of proper supervision and inspection.

In regard to the important question of administrative safeguards, Mr. Sachs maintains that these are by no means as complete as they should be from the fire point of view. There is no reason why structures afloat should not be provided with fire patrols, in a manner similar to that which has been accepted as essential for buildings on land, and in connection with mechanical recording appliances and regular inspection, be considered as a part of the regular equipment. Strict rules should always be formulated and kept especially in connection with crowded steerages and similar conditions. Since this is especially difficult with excursion vessels and boats in which the passengers travel for short periods of time, the importance of extra patrol service for such occasions will be understood.

The necessity for the provision of adequate appliances for the extinguishing of fire will be admitted by all, yet, as Mr. Sachs remarks, there is not much to be said in favor of the fire service equipment on board ship.

"For the ordinary small fire on board ship, nothing is more in place or more effective than the ordinary bucket and hand-pump. The next thing which should be remembered is, that a hydrant, to be effective on board ship, must stand charged at a fair pressure of, say, two atmospheres, and be so placed that it can be immediately brought into action. Pumping water at high pressure is not of such importance during the first few minutes as an efficient stream at a fair pressure,

immediately applied without fuss or trouble.

"Steam-pumps will, of course, be found ready for action on any decent ship nowadays, but really strong and efficient manuals should be placed in positions where a large number of men can easily get at them and efficiently handle them. These would be reliable stand-bys. The inefficient squirty manual of an antiquated type is all too common. Attention should be paid to matters of detail, such as good either-end couplings and good hose. In all ships the hand-pump and hydrant should be accorded premier importance.

"On the cargo boat, however, and on the combined boat, the fire-extinguishing equipments should compulsorily include an extinguishing plant for the application of carbonic acid gas, or some other form of gas. This form of extinguishing is most effective, but it must not, of course, be considered to entirely replace extinguishing by water."

Naturally there will be objection made, on the score of expense, to the proper equipment of vessels with adequate and suitable fire extinguishing appliances. This is the selfish point of view of the owner, but owners are apt to be selfish when the expenditure of money is involved, and Mr. Sachs does not attempt to relieve them from this imputation. On the contrary, he assumes that it is only by showing them that their pockets will not be very severely touched, apparently, that he hopes to gain their attention.

"Even if there be some additional capital outlay in the first instance, the loss of interest thereby involved should be partly made up by a reduction on the underwriting rates, both as to the ship and its cargo. The additional division into compartments is not a great expense. The application of non-inflammable materials, though at first sight an apparently heavy item, involves but a very small percentage on the total expenditure of furnishings and fitments in an up-to-date passenger ship. The expense for the administrative safeguards is minimal, and that for the fire extinguishing equipment likewise. In fact, if only shipowners and shipbuilders would take the matter to heart, they would find that the moment they really wished to make their vessels safer from fire, they would be able to do so at a very small cost; whilst, of course, as long as they look upon the safeguards with disfavour, the extra expense will be described as enormous."

In concluding his paper Mr. Sachs gives a list of vessels injured by fire during the year 1903, and calls attention to the fact that in many cases the report of ships as "missing" has doubtless been due to disaster by fire or which no other record has ever been obtained."

MUNICIPAL TRANSPORT PROBLEMS.

A DISCUSSION OF METHODS OF RAPID TRANSIT IN NEW YORK CITY WITH PROPOSITIONS FOR THEIR IMPROVEMENT.

Walter Wellman.

THE problems of personal transport are to be encountered in all great cities, and London, Paris, and New York have contended with them for many years. The task, however, has appeared to be an up-hill one, and for a good reason; the greater the transport facilities provided the greater the number of people attracted to the part of the city thus served, the remedy but increasing the demand. New York especially is feeling this congestion because of its geographical conditions. Formed like a great wedge enclosed between two wide rivers, with the business portion at the point, it is continually feeling the pressure of the daily tide which flows down in the morning and up in the evening, crowding every available means of transport to the utmost. The limited area of the small end of the wedge has proved no bar to the increase in the number of people therein during business hours, since the construction of buildings of increasing height has provided for present demands. These structures, containing from 1,000 to 6,000 people each, discharge their populations upon the streets and the transport accommodations at about the same time every evening, and the congestion which naturally results has become a matter for serious concern.

In a recently published pamphlet, Mr. Walter Wellman makes some suggestions

which demand consideration in this place, leading as they do to a more radical treatment of the subject than has hitherto been considered.

Reviewing the growth of transport facilities from the stage coach single car, short train, and longer train, Mr. Wellman naturally arrives at the final arrangement, so far as the actual carrying portion of the problem is concerned, and commits himself to the continuous travelling platform. This may be placed either in a subway or on an elevated structure, and it should be provided with loops at the ends of the route, and be given a speed of about 24 miles per hour.

Given such a platform, the question which next arises is the method of transferring the passengers to and from the train at the desired points. One method, to which we shall refer again, is that used at Paris, and elsewhere, of having one or more auxiliary traveling platforms of slower speeds, so that the passengers may step successively from the stationary platform to the one which is moving at full speed, through the medium of the gradual changes. The other, now suggested by Mr. Wellman, includes the use of transferring platforms, these forming a portion of the main traveling platform, and being brought opposite the stations at all the stops.

This plan involves the rising of the passengers from their seats and their walking to the transfer portion of the platform as the station is approached, but it provides the full length of the station platform for the reception and discharge of passengers. It also involves the periodical stopping and starting of the entire platform, a matter which at present constitutes one of the chief difficulties with isolated trains. Mr. Wellman's plan is undoubtedly a vast improvement over the present method of crowding and pushing, but it seems unfortunate that he has not gone further and accepted the continuously moving platform as the true solution of the question. Apparently he is afraid of the matter of obliging the passensengers stepping from a stationary platform to a slow-moving one and from thence to a faster one, and so on. Such a fear is wholly unnecessary. The experience at Paris demonstrated that every one accepted this method as altogether easy and safe. The old and feeble, as well as the youngest children, mounted the travelling sidewalk at the exposition without the slightest hesitation or difficulty, and during the entire period that it was in use there were but two slight casualties; one being the slipping of a lame man and the other the falling of a woman carrying one child with another dragging at her skirt, and neither of these instances had any serious results. Can we say as much for the thousands who daily dodge the surface electric cars in New York to-day?

Mr. Wellman does well in all that he proposes, but he does not propose nearly enough. The travelling sidewalk is the one and only satisfactory solution of the transport problem in New York, but it should be a continuously moving platform, making no stops, except perhaps for one or two hours in the night for inspection and repair. The whole structure should be on an elevated level, giving a second street level, extending from one house line to the other. This would provide a second set of entrances to all shops, etc, and permit the surface of the ground to be employed for heavy traffic and merchandise. The middle of the street should be fitted with a travelling pavement, never stopping, and boarded and left at any point by means of platforms of secondary speed, as at Paris. A large part of the present congestion is due to the existence of landing stations, where the traffic is concentrated, and this should not be permitted, everyone being allowed to get on or off at any point. The capacity of such a platform is immense, and no one would get on at a crowded point when it would be easy to wait a few minutes until a convenient portion came along. The absence of the inertia shocks, due to starting and stopping would mean the removal of a large portion of the cause of wear and tear, all braking appliances being rendered unnecessary, while the ability to alight at the very point desired would go far to improve the service.

The principal objection to such a plan, admitting that there is not the slightest objection to getting on or off of such a platform, lies in the impracticability of collecting fares on a system which has no stations, no obstructing wickets, and no ticket takers. As a matter of fact, none of these obstruct-

ing appliances is necessary. In the tall buildings of New York, Mr. Wellman remarks that the elevator has got far ahead of the street car. He is right, but he has forgotten that there is no special ticket required to ride on an elevator, and that the service is rendered as an essential part of the conduct of a modern office building. At the present time it is held to be one of the duties of a municipality to provide streets and sidewalks for its residents. Before long it may well be required of the same municipality that these same sidewalks shall no longer be stationary, but shall be kept in motion, as well as cleaned, paved, and lighted. With such a service the stream of people will move at a speed demanded by the conditions of modern life, to the benefit of the whole community and the prosperity of the place which has realized that safe and certain transport is one of the essentials of the modern city.

POWER FROM COKE OVEN GASES.

METHODS OF COLLECTING, PURIFYING, AND UTILIZING THE DISCHARGE GASES FROM COKE OVENS FOR THE PRODUCTION OF MOTIVE POWER.

Bergassessor Baum—Glückauf.

So much has been said nad written of late about the utilization of the waste gases from blast furnaces that another source of power for internal-combustion engines has been comparatively overlooked, although not entirely forgotten. In works for the production of illuminating gas the coke is considered as a by-product, but in the vast number of ovens in operation for the production of furnace coke the gas has either been allowed to go entirely to waste, or has been used only in some secondary or by-product process in which its high calorific power has been but partially utilized.

The production of gas by the coke oven varies according to the character of the coal which is coked, and also depends upon the temperature and other conditions of the operation. The leaner coals, which require a high temperature for the production of a satisfactory coke, may furnish but little more gas than is required for the heating of the oven, but in all such cases the use of a portion of the gas to preheat the air will result in a marked economy in the working. Richer coals, requiring a lower temperature for coking, furnish a greater proportion of gas, so that there will be from 20 to 40 per cent. of the gas available for power purposes after the necessary amount for the ovens has been taken. In this connection the injurious effect of moisture in the coal may be observed, a large proportion of the heating value of the gas being required for the vaporization of the moisture. Herr Baum gives results from several coking coals, including those from the Saar district, from Silesia, and from Moravia, from which it is shown that when a smaller proportion of gas is produced it generally has a higher calorific value. The thermal value of the coke-oven gases thus examined varied from 2,000 to 4,335 calories per cubic metre, or about 225 to 485 B. T. U. per cubic foot, so that it is well adapted for use in the gas engine, lying about midway between coal gas and the average of blast furnace gases.

In preparing the coke-oven gas for use in the cylinder of an engine several operations of purification have been found necessary. The principal impurities to be considered are tar, ammonia, cyanogen, and sulphur. To remove these the gases are first passed through a condenser, or surface cooler, by which the temperature is reduced from about 280° C. to 100° to 70° C., this operation causing the condensation of the greater part of the tar. A second system of coolers lowers the temperature to about 25° C., removing the remainder of the tar, this operation being followed by the passing of the gases through scrubbers in direct contact with water for the removal of the ammonia, sulphuretted hydrogen, and cyanogen. A variety of mechanical modifications of these machines have been devised, some of the more important of which are described at length and illustrated at length in the paper of Herr Baum. Other methods of removal of the sulphur and the cyanogen, by means of iron ore, in a manner similar to that employed for

the purification of coal gas, are also described.

The gas is best drawn from the ovens by means of exhausters, several forms, of the rotary type, of which are described, and the gas delivered into holders, the supply from a number of ovens contributing to maintain uniformity of composition. By the use of automatic pressure regulators the supply is maintained at a constant pressure in the mains, and a steady supply delivered to the motors.

Herr Baum gives descriptions of a number of gas engines suited for use with coke-oven gases, these covering practically all the well-known designs, such as those of Otto, Koerting, Oechelhauser, the Nürnberg works, Cockerill, etc., showing their adaptability either for direct-connection with blowing cylinders, or for the driving of electric generators for the production of motive power or for illumination. The latter portion of the paper constitutes a very complete review of the present state of the art of the construction of large gas engines, including valve gears, regulation, and the general subject of combined generating sets composed of gas engines and direct-connected dynamos.

The entire question of the utilization of waste gases, of which but a single portion is considered in this exhaustive paper, is one demanding increasing attention. When the gas engine was first made a practical machine, it was tacitly assumed that it would be used only in connection with illuminating gas as fuel, questions of convenience outweighing those of operative cost. Tests soon demonstrated the high thermal efficiency of the internal-combustion engine, and later experience with special forms of gas producers gave most encouraging results. All this time the fact that metallurgical furnaces were emitting great volumes of fuel gas, especially adapted for use in such motors, was overlooked, and indeed had such sources of supply been considered they could hardly have been utilized until the development of electrical generating, transmitting, and power-application devices rendered them available. At first the idea that the gas engine was adapted for small powers only acted as a hindrance to further progress, but this gradually gave way before the practical demonstrations of successive builders, so that it is now a well established fact that the waste gases from blast furnaces, coke ovens, and other metallurgical furnaces may be employed to great advantage, not only for furnishing the power to drive the blowing cylinders and other machinery of the works in which they are located, but also for providing current for local distribution.

ELECTRIC AND HYDRAULIC DOCK MACHINERY.

COMPARATIVE PERFORMANCES OF ELECTRIC AND HYDRAULIC CRANES FOR CARGO HANDLING AT THE MIDDLESBROUGH DOCK.

Vincent L. Raven—Institution of Mechanical Engineers.

At several meetings of the Institution of Mechanical Engineers the comparative merits of hydraulic and electric power for the operation of hoisting machinery have been discussed, and an interesting paper describing the trials made at the Middlesbrough Dock was presented at the recent meeting of the Institution in Chicago by Mr. Vincent L. Raven, the Chief Assistant Mechanical Engineer of the North Eastern Railway. Since Middlesbrough is an important shipping port for merchandise carried between England and the Continent, the location was an excellent one for determining the successful operation of cargo handling machinery, and the conditions of the trials appear to have been such as to furnish reliable data.

Ever since the development of the hydraulic crane by the late Lord Armstrong, its use has extended in all parts of the world, and there is little doubt that the development of the modern mechanically equipped harbor is largely due to the introduction of this important class of machinery. Of late, however, the rapid development of the electric transmission of power, together with the installation of generating stations for lighting purposes, has led to the introduction of electrically driven cranes and hoists, and hence a rivalry between the two systems has appeared.

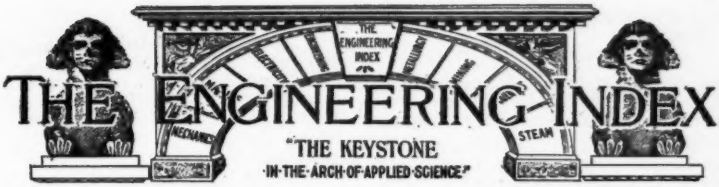
The cranes in use at the Middlesbrough Dock are of a type well known in harbor equipment, consisting of radial jib cranes mounted upon travelling gantries high enough to permit a locomotive and train to pass beneath, the gantry spanning the railway track laid close to the quay wall. This form of crane is most convenient for transferring merchandise from the waggons to the vessels, or vice versa, and with hydraulic power it has been in use at many important seaports. After a number of years' experience, similar cranes with electric power machinery have been installed at Middlesbrough and Mr. Raven has instituted a series of comparative trials in order to determine the respective advantages of the two types. As the hydraulic cranes were some fifteen years old at the time of the installation of the new machines it was thought advisable to have them thoroughly overhauled, and as no changes in design had been made in the general type, the comparison may be considered as fairly satisfactory.

The trials were made to resemble as nearly as possible the actual working conditions of the machines, this being done by lowering into the dock a tub, itself weighing one ton, and holding two tons of water, the load of three tons being hoisted and swung around upon the quay wall and emptied, and then swung back again. Similar trials were made by lifting uniform and variable loads of rails, both types of cranes being subjected to the same tests, and the power required and the time taken in each case being carefully recorded. Such trials enable comparative results to be made more accurately than if the handling of actual loads is timed and measured, since the loads cannot be made uniform in actual service, and other operative conditions affect the time required.

In general the report is highly in favor of the electric machines. Mr. Raven appears to emphasise especially the fact that they are much less wasteful of power, the saving in this respect being from 25 to 50 per cent. over the hydraulic cranes. While this is a matter for examination, it is by no means the main consideration. A much more important feature is found in the greater rapidity of action of the electric cranes. This appears, not only in the greater speed of hoisting and sluing, in which movements a gain of 50 per cent. in time was shown, but also in the greater ease with which the machines could be shifted on the rails and refixed in new positions for operation.

It is in these elements of greater facility of action that the electric machines show their greatest advantage, this feature corresponding to the gain in the use of electric machinery elsewhere. The saving in actual power consumed usually bears a trifling proportion to the gain in money secured by the more rapid handling of the cargo, and the saving in the time of attendants. The power cost, while an element always to be considered, is never so great as the labor cost, while the fixed charges are usually as great as all the other expenses taken together, so that any appliance by which time is saved usually effects a saving much greater than its cost.

There are a number of minor features about the use of electric machinery about docks which appear in Mr. Raven's paper. Thus, in cold weather it is necessary to maintain fires, involving the attendance of caretakers, to prevent the hydraulic machines from injury by freezing, while with the electric cranes no such care is required. The cost of electric distribution of energy is also lower than that of hydraulic power; according to Mr. Raven's estimate this showing a gain of 50 per cent. Altogether the whole report shows so many advantages for the electric machinery that there is every reason to believe that for this special service at least, the hydraulic machinery must take second place. It does not follow from this that hydraulic cranes and hoisting machinery are to be entirely superseded by the electrically driven machines. In the opinion of Mr. Ellington there will always be a place for both types of machines, each supplementing the other. In some cases economy of power will doubtless be the controlling element, but in others, and by far the greater number of instances, economy of time is of far greater value, while in all the question of safety from accident must be considered, since a single disaster might involve a far greater loss of value, not to speak of life, against which the increased cost of working is the cheapest form of insurance.



The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

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CIVIL ENGINEERING

BRIDGES.

Accident.

A Pin Bridge That Stood Without an End Post. John C. Moses. Illustrates and describes a bridge damaged by a railroad accident, and comments by way of explanation are given. 800 w. Eng News—May 19, 1904. No. 62983.

Arch.

The Adolphe Bridge at Luxembourg (Le Pont Adolphe à Luxembourg). M. Sejourné. Brief description of the double masonry arch of 84.65 metrès span. 1200 w. Comptes Rendus—May 2, 1904. No. 62840 D.

The Four Track Stone Arch Bridge of the Pennsylvania Railroad Across the Susquehanna River. Illustrates the bridge at Rockville, and the steel bridge removed, giving information concerning them. 500 w. Sci Am Sup—May 7, 1904. No. 62590.

Bascule.

The Harway Avenue Bascule Bridge, New York City. Illustration and description of bridge over Coney Island Creek, having a clear span of 50 feet, built of

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medium steel. 800 w. Eng Rec—April 30, 1904. No. 62528.

Cairo.

New Bridges at Cairo. Particulars relating to three new bridges to span the Nile. 1400 w. Engr, Lond—May 13, 1904. No. 62777 A.

Designs.

Design of a Fixed-Ended Arched-Rib Highway Bridge. Charles Derleth, Jr. Gives calculations, stress sheets and general drawings for a steel arch-ribbed bridge. Ills. 6500 w. Cal Jour of Tech—May, 1904. No. 62623 C.

I. Effect on Trusses and Plate Girders Due to Imperfect Roller Support. George N. Linday. II. Railway Bridge Calculation by End Shear Table. Josiah Gibson. Two papers with discussions on points in bridge design. 8700 w. Jour W Soc of Engrs—April, 1904. No. 62641 D.

Types and Details of Bridge Construction; Plate Girders. Frank W. Skinner. Presents examples of interesting construction work that has been actually erected, selected with a view to their value to bridge designers, draftsmen, city engineers, and others. 2200 w. Ills. Eng Rec—May 21, 1904. Serial. 1st part. No. 62760.

Erection.

Electric Cable-Way Over the Zambesi River. An illustrated description of an interesting cable-way in Africa, erected to transport material for building the highest bridge in the world across this river, and for making the railway. 1500 w. Engng—April 22, 1904. No. 62420 A.

Fraser River

The Fraser River Bridge, British Columbia. The present article gives an illustrated detailed description of the approaches and plate-girder spans. 2200 w. Eng Rec—April 30, 1904. Serial. 1st part. No. 62522.

Railway Bridge.

The Shubenacadie River Bridge—Midland Railway. J. J. Taylor. An illustrated detailed description of the construction of a single track bridge over a river 1,220 feet wide at the point of crossing, where the tides were extremely high and swift. 8000 w. Can Soc of Civ Engrs, Adv Proof—Jan. 28, 1904. No. 62434 D.

Reinforced Concrete.

A Concrete-Steel Highway Bridge at Plainwell, Mich. P. A. Courtright. Illustrated description of a bridge across the Kalamazoo River, and its construction. 2800 w. Eng News—May 12, 1904. No. 62667.

Melan Concrete Steel Arch Bridge Across the Great Miami River, Dayton, Ohio. Illustrated detailed description of the bridge and its construction. 2800 w. Eng News—May 19, 1904. No. 62978.

Skew.

A Novel Piece of Bridge Construction at Lawrence, Mass. M. F. Brown. Illustrates and describes a novel method of solving the problem of a skew crossing. 1100 w. Eng News—May 12, 1904. No. 62662.

Suspension.

The Elizabeth Suspension Bridge at Budapest (Die Elisabeth-Kettenbrücke in Budapest). Dr. Karl Rosenberg. With details of foundations, construction, and erection. Eye-bar cables are used for a span of 290 metres. Two articles. 3 plates. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—April 22, 1904. No. 62824 each D.

Transporter Bridge.

Transporter Bridge Across the Manchester Ship Canal. Illustrated description of a bridge, nearing completion, which has a clear span of 1,000 feet. 1400 w. Sci Am—May 28, 1904. No. 62958.

Widening.

The Widening of the Birsig Viaduct at Bâle (Die Verbreiterung des Birsigviaduktes in Basel). The roadway is increased in width from 7.5 metres to 16 metres by the addition of auxiliary arches and flooring on each side. 1800 w. Schweiz Bauzeitung—April 23, 1904. No. 62844 B.

CONSTRUCTION.

Armory.

The Fifth Regiment Armory, Baltimore. Illustrated description of the interesting structural features, especially the drill-hall roof. 2400 w. Eng Rec—May 14, 1904. No. 62675.

Building Collapse.

The Collapse of a Building During Construction. H. de B. Parsons. Brief description of the construction and collapse of the Hotel Darlington. Ills. 1600 w. Pro Am Soc of Civ Engrs—April, 1904. No. 62443 E.

Building Construction.

The Construction of the Times Building, New York City. An illustrated general description. The present article deals especially with the foundations and excavation. 3500 w. Eng Rec—April 30, 1904. Serial. 1st part. No. 62524.

Caissons.

Caisson Illness and Diver's Palsy; an Experimental Study. Leonard Hill, and J. J. R. Macleod. Abstract of an article in the *Journal of Hygiene*. On the effects of compressed air on the human system and the cause of the disease known as "the bends," and the method of its prevention. A valuable article. 8000 w. Eng News—May 5, 1904. No. 62574.

Cofferdams.

Interlocking Steel Sheet Piles for

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Bridge Pier Cofferdams. Illustration with detailed description of substructure construction of the Cuivre River bridge, about 60 miles from St. Louis. 1500 w. Eng Rec—April 30, 1904. No. 62526.

Exposition.

The Building of a World's Fair. An illustrated description of how the Louisiana Purchase Exposition has been constructed, with map showing civil engineering works on grounds. 9600 w. Eng Rec—May 7, 1904. No. 62576.

Foundations.

Foundations of the Sturtevant Hotel, New York City. Brief description of deep foundation work where surrounding buildings had shallow foundations, in a congested business district. Ill. 700 w. Eng Rec—May 14, 1904. No. 62680.

Roads.

A Difficult Piece of Road Building. From a report by J. J. Albertson. An account of the building of a road across salt meadows between Pleasantville and Atlantic City. 1200 w. Eng Rec—May 21, 1904. No. 62757.

St. Louis Exhibition.

The Building Construction of the St. Louis Exhibition. Illustrated article describing in detail the construction of these buildings. 6500 w. Eng News—May 19, 1904. No. 62984.

Steel Skeleton.

The Use of Steel in American Lofty-Building Construction. B. H. Thwaite. Read before the Iron & Steel Inst. Briefly reviews the history of the use of iron and steel in building construction, describing the system, and discussing its advantages and disadvantages. 3800 w. Ir & Coal Trds Rev—May 6, 1904. No. 62739 A.

Tunneling.

The Electric Plant at the Karawanka Tunnel (Die Elektrische Anlagen am Karawanken Tunnel). Johann Perl. A full account of the use of electric power in the boring of the tunnel through the Karawanka Alps in Carinthia. The bore is 7,969 metres long. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—May 6, 1904. No. 62825 D.

Tunnels.

The Harlem River Tunnel of the New York Rapid Transit Railroad. The conditions and very shallow depth made the construction difficult, and the methods employed are illustrated and described. The present article describes the work on the second half of the tunnel. 2800 w. Eng Rec—May 14, 1904. No. 62676.

Pennsylvania R. R. Tunnel under North River. An illustrated account of an exhibit at the World's Fair of a full-sized section, showing the construction, concrete lining, screw pile and bridge system, &c., with information concerning this great work. 1700 w. Ry & Engng Rev—May 21, 1904. No. 62797.

MATERIALS OF CONSTRUCTION.

Cement.

The Cement Age: The Many New Uses and Increasing Demand for Plastic Materials. A topical discussion, introduced by R. W. Lesley. 6800 w. Pro Engrs' Club of Phila—April, 1904. No. 62632 D.

Cement Works.

A New Spanish Portland Cement Works. Illustrated detailed description of new works in Spain, built by American engineers and equipped with American machinery, operated entirely by water power. 1800 w. Eng News—May 5, 1904. No. 62570.

Discussion of Published Data on the Thermal Efficiency of the Rotary Kiln, and Possible Reduction of Fuel Requirement. Henry S. Spackman. Gives an analysis of investigations. Also editorial. 4200 w. Eng Rec.—May 14, 1904. No. 62682.

Compression.

The Influence of Lateral Pressure upon the Crushing Resistance of Solids (Influence des Pressions Latérales sur la Résistance des Solides a l'Ecrasement). A. Considère. Data of tests made upon cylinders of mortar, surrounded by hydraulic pressure, and subjected to axial crushing. 1800 w. Comptes Rendus—April 18, 1904. No. 62834 D.

Concrete.

Concrete: Its Properties and Applications. A topical discussion introduced by Edgar Marburg. 13000 w. Pro Engrs' Club of Phila—April, 1904. No. 62633 D.

Loam and Clay in Sand for Concrete. G. J. Griesenauer. Gives a record of tests made, with remarks on the results. 1200 w. Eng News—April 28, 1904. No. 62493.

Making Concrete Water Tight. Editorial discussion giving conclusions drawn from experiments of various investigators. 2200 w. Eng News—May 19, 1904. No. 62979.

Reinforced Concrete.

Reinforced Concrete in Building Construction. Emile G. Perrot. Calls attention to the application of this material to building construction, particularly to factory or mill building, discussing it from the architects' standpoint, and showing the advantages and drawbacks incident to its use. General discussion. Ills. 6800 w. Pro Engrs' Club of Phila—April, 1904. No. 62634 D.

Tests to Destruction of a Ferro-Concrete Truss. From *Annales des Ponts et Chaussees.* Describes tests of a regular open-work truss built entirely of ferro-concrete at Ivry, and tested to destruction.

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1200 w. Engng—April 22, 1904. No. 62416 A.

Test to Destruction of a 65-ft. Truss Bridge Span of Reinforced Concrete. Abstract from *Annales des Ponts et Chaussées*, concerning a test made by Mr. Considère, describing the test structure, and giving results of tests. Ills. 2000 w. Eng News—May 5, 1904. No. 62571.

The Cottancin System of Armoured Construction. A. R. Galbraith. From a paper read before the Society of Architects. States the advantages claimed for these methods of armoured construction, the uses to which they are applied, results, &c. 3800 w. Archt, Lond—April 29, 1904. No. 62596 A.

See also Civil Engineering, Bridges.

Slag.

The Utilization of Blast Furnace Slag. E. R. Sutcliffe. Abstract of a paper read before the West of Scotland Ir. & Steel Inst. Describes the methods of making building bricks and artificial paving materials. Ills. 4800 w. Ir & Coal Trds Rev—April 15, 1904. No. 62393 A.

MEASUREMENT.

Geodesy.

Report of the Commission upon the Geodetic Operations at the Equator (Rapport Presente au Nom de la Commission Chargée du Controle Scientifique des Opérations Géodesiques de l'Equateur). Progress report of the Commission of the French Academy upon work done in Ecuador during 1903. 2500 w. Comptes Rendus—April 25, 1904. No. 62836 D.

The Determination of Difference of Longitude by Transport of Timepieces (Essai d'une Détermination de Difference de Longitude par Transport de l'Heure). Paul Ditisheim. A determination of the difference in longitude between Paris and Neuchatel by transport of chronometers provided with compensated balances of nickel-steel alloy. 1200 w. Comptes Rendus—April 25, 1904. No. 62837 D.

The Present Status of Geodesy (L'Etat Actuel de la Géodésie). R. Bourgeois. A review of the latest methods of accurate base and angle measurement, with especial reference to the work of the French equatorial expedition. 5000 w. Rev Gen des Sciences—April 30, 1904. No. 62842 D.

Land Surveys.

Origin of the United States Land Surveys. W. A. Truesdell. Information concerning the early public surveys of this country. 3500 w. Jour Assn of Engng Socs—April, 1904. No. 62628 C.

Surveying.

Recent Methods of Hydrographic Surveying. A. S. Cooper. Briefly describes recent important developments, discussing their accuracy and cost. 1200 w. Eng News—May 19, 1904. No. 62980.

Tractograph.

Wide Tire Tests. Lawson M. Fuller. Report of a Board of Officers of the Ordnance Department of the United States army, describing the tractograph used and results obtained. 2000 w. Munic Jour & Engr—May, 1904. No. 62539 C.

MUNICIPAL.

Municipal Plant.

Tullahoma, Tenn., Water and Light Plant. Granbery Jackson. Brief history and description of a high voltage transmission line, with report of results obtained. 2800 w. Munic Engng—May, 1904. No. 62437 C.

Pavements.

Brick Pavement Construction. Ira O. Baker. Calls attention to neglected details, discussing the width of pavement, the subgrade, foundations, brick, cushion, and joint filler. 3000 w. Munic Jour & Engr—May, 1904. Serial. 1st part. No. 62540 C.

Records.

Sewer Contractor's Records. Ernest McCullough. Describes a method developed by the writer. 900 w. Eng News—May 19, 1904. No. 62982.

Sewage Disposal.

A Bird's-Eye View of Some Twenty-five British Sewage Works. Brief accounts with general comments. 3000 w. Eng News—May 12, 1904. No. 62663.

Practical Points in Sewage Disposal Works. Extracts from a paper by Henry C. H. Shenton, before the Soc. of Engrs., discussing the latest practice, particularly from the point of view of an engineer. 3000 w. Eng Rec—May 14, 1904. No. 62683.

Sewers.

A Reinforced Concrete Sewer at Wilmington, Delaware. T. Chalkley Hatton. Illustrated description of the sewer and its construction. 2500 w. Eng Rec—May 21, 1904. No. 62753.

Extensions of the Brooklyn Sewerage System; Ninety-Second Street Trunk Sewer. Begins an illustrated detailed description of a large sewer under construction, which will drain a territory of about 1,904 acres. 4000 w. Eng Rec—April 30, 1904. Serial. 1st part. No. 62525.

Extensions of the Brooklyn Sewerage System; Sixtieth Street Sewer. Describes the construction of a sewer built in open cut, although the trench has a maximum depth of 43 ft., and the minimum depth is 34 ft. 2000 w. Eng Rec—May 21, 1904. No. 62756.

The Cleaning and Flushing of Sewers. From a discussion at the annual meeting of the Sanitary Section of the Boston Society of Civil Engrs. 1200 w. Eng Rec—April 30, 1904. No. 62529.

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The Design and Construction of the Proposed Sewer System for Darmstadt (Der Bau von Entlastungs Kanälen und die Grundlagen des Neuprojektes der Kandisation von Darmstadt). H. Heyd. With map, showing the location of collectors, and the details of drainage. 6000 w. 1 plate. Gesundheits-Ingenieur—April 30, 1904. No. 62871 B.

WATER SUPPLY.

Aqueducts.

Important Considerations in the Designing of Large Aqueducts. Extracts from Appendix III. of the report of the commission on an additional water supply for New York City, in regard to economies in construction and improvements in design of the proposed aqueduct. 2700 w. Eng Rec—May 21, 1904. No. 62754.

Boston.

Report on the Measurement, Consumption, and Waste of Water Supplied to the Metropolitan Water District. Report on the supply of Boston and adjacent towns. Dexter Brackett. 13000 w. Jour N Eng W-Wks Assn—June, 1904. No. 62922 F.

Color.

Studies of Color in Water; Metropolitan Water Supply, Massachusetts. Ernest G. Hopson. Discusses means tried for reducing color, and the action in Massachusetts for the prevention of coloring. 4600 w. Eng News—April 28, 1904. No. 62494.

Croton Works.

Progress Report on the Croton River Works for New York City's Water Supply. Information from the report of J. Waldo Smith, giving the present condition of this great work. Ills. 1800 w. Eng Rec—May 7, 1904. No. 62577.

Danville, Ill.

Filter Plant and Other Improvements for the Water Supply of Danville, Ill. Illustrated description of dam, mechanical filter plant, increase in pumping capacity and distribution, &c. 3300 w. Eng News—April 28, 1904. No. 62489.

Filtration.

A Mechanical Filtration Plant for Watertown, New York. Illustrated detailed description of this plant, with information related. 3500 w. Eng Rec—May 21, 1904. Serial. 1st part. No. 62755.

Note upon the Operation of Sand Filters (Contribution à l'Etude des Filtres à Sable). M. Marboutin. A study of the action of open sand filters by an examination of the proportion of dissolved oxygen in the filtered water. 1200 w. Comptes Rendus—April 18, 1904. No. 62835 D.

Hawaii.

Methods of Obtaining Water Supply for Sugar Plantations in the Hawaiian Islands. J. N. S. Williams. Describes methods of irrigation in a country very much cut up by gulches, and on islands where an artesian supply was available. Ills. 3000 w. Can Min Rev—April 30, 1904. No. 62500 B.

Irrigation.

Notes on Egyptian Irrigation. Information concerning the various engineering works carried out in different parts of Egypt. 4500 w. Builder—April 23, 1904. No. 62398 A.

Metering.

Rates for Metered Water. A topical discussion, opened by Freeman C. Coffin. 8000 w. Jour N Eng W-Wks Assn—June, 1904. No. 62926 F.

The Detection and Prevention of Water Waste at Marion, Ohio. Edward H. Cowan. Explains the policy adopted in establishing meters, and the results. 2500 w. Jour N Eng W-Wks Assn—June, 1904. No. 62924 F.

Water Consumption in Pittsburg and the Probable Effect of Metering. Gives information regarding water consumption in various cities, compiled with the view of showing the relation between per capita consumption and the installation of meters. 2500 w. Eng Rec—May 14, 1904. No. 62678.

Ozone.

Purification of Potable Water by Means of Ozone. Dr. Gg. Erlwein. Read before the Deutscher Verein von Gas und Wasserfachmaennern. An illustrated account showing what may be expected of the employment of ozone in connection with sterilization of water. 3500 w. Sci Am Sup—April 30, 1904. Serial. 1st part. No. 62535.

Pipes.

The Life of Cast-Iron Pipe. C. Cavallier. An account of the condition of pipes in Paris after being nearly 30 years in service, with notes on old water pipe systems in France. 1200 w. Jour N Eng W-Wks Assn—June, 1904. No. 62925 F.

Protection.

Preventing the Growth of Algae in Water Supplies. Extracts from Bul. No. 64, Dept. of Agriculture, by George T. Moore and Karl F. Kellerman, on the use of copper sulphate for the treatment of water supplies, with comments and editorial. 9500 w. Eng News—May 26, 1904. No. 62964.

The Lines of Defence in the Protection of Water Supplies. J. Cartwright. An article by an English engineer discussing the best means of protecting the supply of cities. Also editorial referring to American conditions. 3300 w. Eng News—April 28, 1904. No. 62490.

We supply copies of these articles. See page 719.

Pumping Engines.

See Mechanical Engineering, Hydraulics.

Reservoirs.

Some Notes on Cost of Waterproofing the Concrete Lining of Reservoirs. W. C. Hawley. Discusses the Sylvester process and variations of it, describing the application made and giving cost. General discussion. 3500 w. Jour N Eng W-Wks Assn—June, 1904. No. 62923 F.

St. Louis.

The Water-Works at St. Louis. An illustrated description of the water tower, settling basins, pumping station, pumping engine, &c. 3300 w. Engr, Lond—May 13, 1904. No. 62773 A.

Sedimentation.

On Sedimentation. Allen Hazen. A discussion of the subject from a theoretical standpoint, giving computations which show the reasons for several forms of construction now used. 10700 w. Pro Am Soc of Civ Engrs—April, 1904. No. 62441 E.

Tower Collapse.

A Water Tank Tower and Its Collapse. Illustrates and describes the tower collapse at Abilene, Tex., discussing the faulty design. 1200 w. Eng News—May 19, 1904. No. 62981.

Underground Waters

Underground Waters Adjacent to Surface Streams. C. G. Hubbell. Concerning subsurface waters along large water courses as a pure supply, and the methods of obtaining this water. 1000 w. Eng News—April 28, 1904. No. 62491.

WATERWAYS AND HARBORS.

Canals.

A New Ship Canal at South Buffalo. Illustrates and describes interesting engineering features. 1000 w. R R Gaz—May 27, 1904. No. 62966.

Canals and Navigable Waterways of Belgium. Interesting information from a recent report by Consul-General Hertslet. 3300 w. Col Guard—May 6, 1904. No. 62714 A.

The New Canal Plans (Die Neue Kanalvorlage). A review of the latest plans for a system of internal waterways in Germany, with estimates of cost, and extensive maps. 4000 w. 4 plates. Glückauf —April 23, 1904. No. 62846 B.

Canal Traction.

Electric Towing and the Electric Traction System on the Teltow Canal (Elektrische Treideleiversuche und Einführung des Elektrischen Schleppbetriebes auf dem Teltowkanal). Erich Block. With numerous illustrations of traction motors for canal service and results of tests of performance. 4000 w. Glasers Annalen—April 15, 1904. No. 62829 D.

Dam.

The Gatun Dam. C. D. Ward. Map and suggestions for a dam at this point on Panama Canal, if investigations show it to be more desirable than the Bohio project. 2000 w. Pro Am Soc of Civ Engrs—April, 1904. No. 62442 E.

Docks.

Floating Transfer Dock at Barcelona (Le Dock Flottant à Transfert de Barcelone). Daniel Bellet. With illustrations of the 6,000 ton off-shore depositing dock in actual service. 2000 w. Revue Technique—May 10, 1904. No. 62820 D.

The Stuyvesant Docks at New Orleans. An illustrated detailed description, with general plan of docks and yards. 800 w. R R Gaz—May 13, 1904. No. 62670.

Drainage.

Progress of Construction of the New Orleans Drainage System. Information from the last semi-annual report of the Sewerage and Water Board in regard to the progress. 1800 w. Eng Rec—April 30, 1904. No. 62527.

Dredge.

The Hydraulic Dredge. "J. Israel Tarte." A. W. Robinson. An illustrated detailed account of this dredge and of the work on which it is engaged on the St. Lawrence River. 6000 w. Can Soc of Civ Engrs—Adv. Proof. No. 62436 D.

Floods.

The Subsidence of Floods in Rivers (Sur les Décrues des Rivières). Edmond Mallet. A comparison of observations upon the relative subsidence of swollen streams in cold and warm seasons. 1000 w. Comptes Rendus—April 25, 1904. No. 62838 D.

Nile.

The Nile Dams (Die Stauwerke des Nils). A general account of the works at Assouan and Assiout, with map, sections, and photographs. Two articles. 3000 w. Schweiz Bauzeitung—April 16, 23, 1904. No. 62843 each B.

Whirlpools.

The Direction of Rotation of Whirlpools in the Rivers of Central Europe (Sur le Sens de Rotation des Tourbillons d'Eaux Courantes dans l'Europe Centrale). Jean Brunhes. A communication to the French Academy calling attention to the fact that 90 per cent. of the whirlpools revolve in the opposite direction to the hands of a watch. 1500 w. Comptes Rendus—April 11, 1904. No. 62833 D.

MISCELLANY.

Engineering Works.

Some Early Engineering Works in Pennsylvania. Edwin F. Smith. An il-

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lustrated review of early work, and the difficulties met and overcome. 7000 w. Pro Engrs' Club of Phila—April, 1904. No. 62631 D.

ELECTRICAL ENGINEERING

COMMUNICATION.

Protection.

The Protection of Telephone or Telegraph Lines When in Hazardous Proximity to High Tension Lines. Robert E. Chetwood, Jr. Illustrates and describes the most modern practice of the Bell Telephone system, explaining methods of cross-arm construction designed to reduce the possibility of accident. 1300 w. Elec Wld & Eng—May 21, 1904. No. 62947.

Recorder.

The Electro-Capillary Recorder for Cable Purposes. J. Tarbotton Armstrong and Axel Orling. Illustrated description of an instrument which the inventors claim will enable them to receive 400 to 500 letters per minute. 1100 w. Page's Mag—May, 1904. No. 62780 B.

Railway Service.

Improvements in Telephony and Telegraphy for Railways (Neuerungen in Telephonie und Telegraphie für Eisenbahnen). Dr. Ebeling. Describing improved signal systems, rapid printing telegraphs, Pupin coils, etc., and their special application to railway service. 4500 w. Glasers Annalen—May 1, 1904. No. 62831 D.

Space Telegraphy.

Methods for Increasing the Transmitter Energy of Wireless Telegraph Systems. Prof. Ferdinand Braun. Discusses increasing the energy by increasing the capacity, and also by raising the charging voltage, and describes improved methods. 2000 w. Elect'n, Lond—April 22, 1904. No. 62414 A.

The Application of Resonance Transformers in Space Telegraphy (Ueber Resonanzinduktorien und ihre Anwendung in der Drahtlosen Telegraphie). Dr. Georg Seibt. A mathematical examination of the process of tuning transmitters and receivers. 7500 w. Elektrotech Zeitschr—April 7, 1904. No. 62852 B.

The Metamorphosis of Wireless Telegraph Apparatus. A. F. Collins. A review of the changes and improvements which have been made in space telegraphy during the past seven years. 5000 w. Engineering Magazine—June, 1904. No. 62884 B.

Wireless Telephony with the Aid of the Selenium Cell (La Téléphonie sans Fil au Moyen des Piles à Selenium). A. Gradenwitz. A review of the experiments of Ruhmer by which articulate messages have been transmitted over a space of 7 kilometres. Two articles. 3000 w. Revue Technique—April 25, May 10, 1904. No. 62816 each D.

Telegraph.

The Donald Murray Rapid Telegraph (Ueber den Schnell telegraphen von Donald Murray). A. Kraatz. With numerous illustrations of the perferator, transmitter and receiver, as used in the Royal telegraph offices. 6000 w. Elektrotech Zeitschr—April 28, 1904. No. 62857 B.

Telephony.

Automatic Telephone Exchange of the Northeastern Telephone Company at Portland, Me. Reviews the history of the company and gives an illustrated description of the new exchange. 1400 w. Am Elect'n—May, 1904. No. 62501.

The Plant of the Kansas City Home Telephone Company. Max Loewenthal. An illustrated description of the exchange and its equipment with an account of the formation of the company. 2500 w. Elec Wld & Engr—April 30, 1904. No. 62549.

DISTRIBUTION.

Drop.

The Determination of Drop in Voltage in Parallel Three-Phase Lines (Zur Bestimmung des Induktiven Spannungsabfalles Paralleler Drehstromleittingen). Leo Lichtenstein. A mathematical discussion, showing possible sources of error in voltage measurements. Two articles. 6000 w. Zeitschr f Elektrotechnik—April 24, May 1, 1904. No. 62869 each D.

Earthing.

Earth Returns for High-Potential Currents. From the *Elektrotechnische Zeitschrift.* A report of experimental investigations. 1500 w. Elec Engr, Lond—May 13, 1904. No. 62772 A.

Factories.

Electric Distribution to Small Manufactories at Sant Mortier, France. Franz Koster. An illustrated description of an hydro-electric plant which furnishes power to many small consumers. 2500 w. Elec Wld & Engr—April 23, 1904. No. 62452.

High Voltage.

The Prevention of Crosses Between Signalling and High-Voltage Circuits. Howard S. Knowlton. Considers some of the dangers due to the increasing number of circuits carrying high-potential currents, and the methods of preventing them. 2500 w. Elec Wld & Engr—April 23, 1904. No. 62455.

Insulated Wires.

How Insulated Wires and Cables Are Made. Henry A. Morss. Illustrates and

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describes the manufacture of rubber insulated wires and cables. 3800 w. Cent Sta—May, 1904. No. 62693.

Networks.

The Rational Computation of Current Distributing Networks (Die Rationelle Berechnung von Stromverteilungsnetzen). Dr. E. Müllendorff. A mathematical investigation to determine the relation between the central station and the consumers for a minimum expenditure of copper. Two articles, 7000 w. Elektrotech Zeitschr—April 14, 21, 1904. No. 62853 each B.

Power.

Some Economic Aspects of Electrical Power Distribution. Edmund L. Hill. Abstract of a paper read before the South Wales Inst. of Engrs. The advantages of the power distribution companies in Great Britain are discussed, and the value of the diversity factor to a power company. 2000 w. Ir & Coal Trds Rev—April 15, 1904. No. 62394 A.

Wiring.

The Wiring of Exposed Steel Frame Buildings. Arthur B. Weeks. Sketches and notes describing methods used. 1500 w. Am Elect'n—June, 1904. No. 62977.

ELECTRO-CHEMISTRY.

Electric Smelting.

Electric Smelting Experiments for the Manufacture of Ferronickel from Pyrrhotite. Ernst A. Sjostedt. Read at meeting of the Am. Elec-Chem. Soc. An account of electric smelting experiments made at Sault Ste. Marie. Ills. 2400 w. Elec Rev, N. Y.—May 14, 1904. No. 62659.

Electrometallurgy in the Iron Industry (Electrometallurgic. Industrie du Fer). L. Francois and L. Tissier. The first of a series dicussing the production of iron and steel in the electric furnace. 2000 w. Revue Technique—May 10, 1904. No. 62821 D.

Some Electric Furnace Processes. J. Wright. Deals with some of the more important industries which have been made possible by the intense heat of the electric furnaces. Ills. 7200 w. Cassier's Mag—May, 1904. No. 62782 B.

The Electric Smelting of Iron Ores. Gives the conclusions of the best authorities who have investigated this subject. 2000 w. Can Min Rev—April 30, 1904. No. 62497 B.

The Electric Steel-Furnace at Gysinge, Sweden. F. A. Kjellin. Illustrated description of the furnace and smelting process. 1600 w. Trans Am Inst of Min Engrs—Oct, 1903. No. 62939.

Electrodes.

Electrodes of Artificial Graphite (Ueber Elektroden aus Künstlichem Graphit). Dr. Alfred Gradenwitz. A comparison of natural and artificial graphites as electrodes in commercial electrolytic operations. 1500 w. Elektrotechnische Zeitschr—May, 1904. No. 62864 G.

Electro-Metallurgy.

Electrolytic Iron. Prof. C. F. Burgess and Carl Hambuechen. Read at the Washington meeting of the Electro-chemical Soc. A report of experimental investigations of the conditions suitable for electrolytically depositing iron, showing that it can be produced in such quantities and at such cost as to make it of commercial importance. 2300 w. Sci Am Sup—May 7, 1904. No. 62593.

Rectifiers.

Electrolytic Rectifiers for Charging Storage Batteries with Alternating Current. Charles F. Burgess. Read at Milwaukee meeting of the N. W. Elec. Ass'n. An explanation of the properties and peculiarities of the electrolytic rectifier. 2500 w. Sci Am Sup—April 30, 1904. No. 62534.

Storage Batteries.

Storage Battery Plate Construction with Special Reference to High Discharge Characteristics. W. W. Donaldson. Considers the construction of plates best adapted to high discharge work. 3000 w. Elec Wld & Engr—May 21, 1904. No. 62950.

Zirconium.

The Production of Crystallized Zirconium in the Electric Furnace (Ueber die Darstellung des Sogen. Kristallisierten Zirkoniums im Elektrischen Ofen). E. Wedekind. With a discussion of the reactions, and microphotograph of the crystalline effect. 2000 w. Zeitschr f Elektrochemie—May 6, 1904. No. 62866 G.

ELECTRO-PHYSICS.

Alternating Currents.

The Braun Tube in the Study of Alternating Currents. Describes the Braun tube, explaining its use for this purpose, referring to experiments carried out by Prof. A. Petrovski. Ills. 2000 w. Elec Wld & Engr.—April 30, 1904. No. 62551.

Direct-Current.

The Pulsation of the Direct-Current Output of Rotary Converters. Translation in abstract of an article by R. Elsasser in *Elektrotechnische Zeitschrift.* An attempt to show that the chief cause of the pulsations is the superposition of the ohmic voltage drops due to the direct current and the alternating current within the armature conductors. 2000 w. Elec Engr, Lond—April 29, 1904. No. 62604 A.

Radioactivity.

Radioactive Substances (Ueber Radioaktive Stoffe). W. Marckwald. An address before the Elektrotechnische Verein,

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giving a general account of the present knowledge of radioactive materials. 7500 w. Elektrotech Zeitschr—April 2, 1904. No. 62855 B.

The Preparation of Radium, Vanadium and Uranium Compounds from Carnotite and Pitchblende. J. Ohly. Explains methods and observations made, giving conclusions. 2000 w. Min Rept—May 12, 1904. No. 62695.

GENERATING STATIONS.

Alternators.

Theoretical Basis for the Experimental Pre-Determination of the Regulation of Alternators. Dr. Theo. Torda-Heymann. Describes a method which the writer considers will more nearly coincide with actual facts, applying it to examples given by B. A. Behrend in an earlier article. 1600 w. Elect'n, Lond—April 22, 1904. No. 62413 A.

The Oscillation of Parallel-Connected Alternators (Das Pendeln Parallel Geschalter Wechselstrommaschinen). A. Sommerfeld. A mathematical analysis of the phenomena of surging in parallel running of alternators. Two articles. 10000 w. Elektrotech Zeitschr—April 7, 14, 1904. No. 62851 each B.

Steam Alternator at Bedford. Illustrations with brief description. 1400 w. Engr, Lond—May 6, 1904. No. 62725 A.

Central Station.

A Rapidly Growing Western Central Station. E. A. Barth. Illustrated description of the generating plant of the Kansas City Electric Light Company. 5800 w. Am Elect'n—June, 1904. No. 62971.

Some Aspects of New England Central Station Development. An illustrated article giving an interesting account of the development and transmission of electric energy. 8000 w. Elec Wld & Engr—May 21, 1904. No. 62944.

The Combined Use of Alternating and Direct Current for Central Station Work. F. C. Caldwell. Read before the Ohio Elec. Soc. States the conditions that have led to the combined use, considering the question from the point of view of the consumer, the distribution and the station. 3300 w. Engr, U S A—May 15, 1904. No. 62699.

The Present Possibilities of the Gas Producer and Gas Engine for Central Station Purposes. Discusses the subject from the viewpoint of conditions in England. 1400 w. Elec Rev, Lond—April 29, 1904. No. 62605 A.

Charges.

The Question of Charges for Electricity Supply (Beitrag zur Tariffrage der Elektrizitätswerke). H. Schönborn. With diagram showing the variation in consumption and its influence upon charges. 2500 w. Elektrotech Zeitschr—May 12, 1904. No. 62861 B.

Design.

Notes on the Design and Construction of Buildings Connected with the Generation and Supply of Electricity Known as Central Stations. Charles Stanley Peach. Also discussion, illustrations and 20 plates. 2300 w. Jour Roy Inst of Brit Archts—April 2, 1904. No. 62397 H.

Power Station Design. C. H. Merz and William McLellan. Abstract of a paper read before the Inst. of Elec Engrs. Discusses the unnecessary expenditure often bestowed on the power station, considering the main principles governing the design, and discussing the effects on actual design. 4500 w. Elect'n, Lond—April 29, 1904. Serial. 1st part. No. 62610 A.

Fire Hazards.

The Reduction of Fire Hazards in Electric Plants. Howard S. Knowlton. Discussing especially the relation of electricity to fire risks, with a review of methods which minimize the hazards from this source. 3500 w. Engineering Magazine. June, 1904. No. 62883 B.

Hydro-Electric.

Hudson River Power in Albany, Troy and Schenectady. An illustrated detailed account of the interesting power developments around Albany. Relates to the utilization of the power at various points. Also editorial. 4300 w. Elec Wld & Engr—May 14, 1904. No. 62701.

The Electric Power Station of the New Richmond Roller Mills Company. R. D. Thomas. Illustrated description of a small hydroelectric plant in Wisconsin. 1600 w. Elec Rev, N. Y.—April 30, 1904. No. 62487.

The Snoqualmic Falls and White River Power Developments. An illustrated account and description of the properties of this company. 4000 w. Elec Wld & Engr—May 7, 1904. No. 62650.

The Utilization of the Water Power of the Glommen at Kykkelsrud (Die Ausnutzung der Wasserkräfte des Glommens bei Kykkelsrud). I. H. Kinbach. A fully illustrated account of the extensive hydroelectric station in Norway, where 44,000 horse-power is being developed. Two articles. 6000 w. 1 plate. Zeitschr d Ver Deutscher Ing—April 23, 30, 1904. No. 62802 each D.

South Boston.

Expansion of the Boston Edison System. Illustrated detailed description of the steam turbine station at South Boston, which is to have a capacity of 60,000 kilowatts. 6500 w. Elec Wld & Engr—May 21, 1904. No. 62943.

The New Generating Station of the Edison Electric Illuminating Company. Illustrated detailed description of the steam turbine plant on L street, South Boston, Mass., and its relation to the Edison Com-

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pany's system. 6000 w. Elec Rev, N. Y. —May 21, 1904. No. 62789.

Sparking.

The Computation of Equipotential Connections (Ueber die Berechnung von Aequipotentialverbindungen). Arthur Müller. A discussion of methods for the prevention of sparking of commutators. Two articles. 5000 w. Zeitschr f Elektrotecknisch—April 17, 24, 1904. No. 62867 each D.

Synchronizer.

The Construction of a Two-Phase Synchronizer. Paul C. Percy. Drawings and description of a two-phase synchronism indicator of the "revolving light" type. 1500 w. Am Elect'n—June, 1904. No. 62975.

Works.

Description of the Grimsby Corporation Electricity Works. Walter A. Vignoles. Ills. 2500 w. Elec Engr, Lond—May 6, 1904. No. 62710 A.

LIGHTING.

Arc Lamps.

Small Candle-Power Enclosed-Arc Lamps for City Street Lighting. J. H. Hallberg. Facts relating to these lamps and their success for street lighting. 3000 w. Am Elect'n—June, 1904. No. 62973.

The Magnetite Arc Lamp. Charles Proteus Steinmetz. Illustrated description of this new illuminant, with explanation of the operation. 1200 w. Elec Wld & Engr —May 21, 1904. No. 62949.

Contract.

New York Retail Contract. George T. Hanchett. An explanation of the details of the contract upon which electricity for lighting is sold. 2000 w. Cent Sta—May, 1904. No. 62691.

Illumination.

Electrical Illumination of the Louisiana Purchase Exposition. Cloyd Marshall. Describes features of exterior and interior lighting. Ills. 1200 w. Elec Wld & Engr —May 21, 1904. No. 62948.

Fallacies in Illumination. E. Leavenworth Elliott. A number of curious and amusing fallacies are explained. 2200 w. Cent Sta—May, 1904. No. 62692.

Improvements in the Technology of Illumination (Neuerungen der Beleuchtungs technik). W. Wedding. A comparison of the illuminating value of various sources of light, on a basis of operative cost and effect. 2000 w. Zeitschr d Ver Deutscher Ing—May 7, 1904. No. 62809 D.

The Transmission of Light Waves of Various Lengths through Fog (Untersuchungen über die Durchlässigkeit von Nebel für Lichtstrahlen von Verschiedener Wellenlänge). A. Rudolph. Data and results of exhaustive experiments showing the greater penetrating power of rays from the red end of the spectrum. 2500 w. Zeitschr d Ver Deutscher Ing—April 30, 1904. No. 62806 D.

Lamps.

A Resumé of Incandescent Electric Lamp Exhausting. S. E. Doane. Brief review of the history of the development of this art, especially considering the present chemical exhausting method. 4000 w. Elec Wld & Engr—May 21, 1904. No. 62945.

The Problems of Improving Electric Lamps. Henry Noel Potter. Reviews the six prominent systems of electric lighting, studying the problems of each with a view to their improvement. 3500 w. Elec Rev, N. Y.—May 21, 1904. No. 62788.

Mercury Arc.

A New Mercury-Arc Lamp with Automatic Starter (Eine Neue Quecksilberbogenlampe mit Automatischer Zündung). Dr. Heinrich Paweck. The mercury tube is mounted on a vertical axis, and started by rotating it; this breaking a mercury short circuit, and causing the current to pass through the vapor. 2000 w. Zeitschr f Elektrochemie—April 29, 1904. No. 62865 G.

Nernst.

Street Lighting by Nernst Lamps. Henry Joseph. Aims to show that, under favorable conditions, with the use of Nernst lamps, it is possible to produce a better light than that given by incandescent mantles at a smaller annual cost and profit. 3000 w. Elec Rev, Lond—May 13, 1904. No. 62770 A.

The Nernst Lamp. An illustrated review of the development of this lamp, with account of its efficiency, regulation, &c. 5400 w. Elec Wld & Engr—May 21, 1904. No. 62951.

MEASUREMENT.

Conductivity.

The Conductometer. Rollo Appleyard. A defence of this instrument invented by the writer, in reply to a recent paper by John Rymer-Jones. 1300 w. Elec Rev, Lond—May 13, 1904. Serial. 1st part. No. 62771 A.

The Measurement of Electrical Conductivity. J. Rymer-Jones. The present article considers the use of the conductometer, and the ordinary meter-bridge, and the objections to them, as introductory to another system to be described later. 1500 w. Elec Rev, Lond—April 29, 1904. Serial. 1st part. No. 62608 A.

Counter.

A New Mechanical Apparatus for Computing Current Consumption (Ueber einen Neuen Apparat für die Mecanische Herstellung von Stromrechnungen für Elektrizitätswerke). F. Biermann. Describing a form of mechanical counter for sum-

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ming up the reading of electric meters, and reducing the clerical labor. 3500 w. Elektrotech Zeitschr—May 5, 1904. No. 62860 B.

Diagrams.

Operating Diagrams of an Alternator (Sur les Diagrammes de Fonctionnement d'un Alternateur). C. F. Guilbert. Discussing methods of constructing the characteristic curves of alternating-current dynamos. Serial. Part I. 2500 w. Revue Technique—April 25, 1904. No. 62819 D.

Indicators.

Construction of a Three-Phase Synchronizer. Paul C. Percy. Illustrates and describes in detail how a useful synchronism indicator may be produced. 1300 w. Am Elect'n—May, 1904. No. 62503.

Oscillographs.

Recording Alternating-Current Wave-Forms by Duddell Oscillographs. Illustrates and describes the instrument and its uses. 3000 w. Sci Am Sup—May 28, 1904. No. 62961.

Recording Instruments.

Curve Drawing or Graphic Recording Instruments. H. W. Young. Explains the value of these instruments, describing the more important ones. 4000 w. Am Elect'n—June, 1904. No. 62974.

Reichsanstalt.

The Physical Technical Reichsanstalt (Die Physikalisch-Technische Reichsanstalt). An abstract of the work of the Reichsanstalt, to the close of 1903, with especial reference to the calibration of electrical instruments. 5000 w. Elektrotech Zeitschr—May 12, 1904. No. 62863 B.

The Work of the Electric Testing Office (Bekanntmachung über Prüfungen und Beglaubigungen durch die Elektrischen Prüfämter). Detailed report of tests of meters at the Reichsanstalt. 5000 w. Elektrotech Zeitschr—April 28, 1904. No. 62856 B.

Resistance.

Measurement of the Insulation Resistance of an Electric Wiring System. Edwin F. Northrup. Describes a voltmeter method and also a galvanometer method applicable for determining the insulation resistance of each side of any wiring system while the power is on. 900 w. Elec Wld & Engr—May 21, 1904. No. 62946.

Three-Phase.

The Measurement of Three-Phase Currents (Sur la Mesure de la Puissance des Courants Triphasés). Maurice Soubrier. Describing the method of connecting totalizing wattmeters for three-phase currents. 2000 w. Revue Technique—April 25, 1904. No. 62818 D.

Torque.

A Convenient and Economical Electrical Method for Determining Mechanical Torque. A. S. McAllister. Explains a method which is very accurate and applicable to all types of motors. 1400 w. Elec Wld & Engr—May 7, 1904. No. 62654.

Wattmeters.

Testing Recording Wattmeters. George T. Hanchett. Explains a method of testing and its value. 1300 w. Am Elect'n—June, 1904. No. 62976.

MOTORS.

Design.

Design of Continuous-Current Motors for Variable Speed. Franklin Punga. An explanation of the lines on which variable-speed motors should be built. 2300 w. Elec Rev, Lond—April 22, 1904. No. 62412 A.

Design of a 6-Horse-Power, Two-Cycle Motor. H. B. Maxwell. A set of working drawings for a 4¼ by 5 inch two-cycle motor that will develop 6 brake horsepower. 800 w. Marine Engng—May, 1904. Serial. 1st part. No. 62461 C.

Induction Motors.

The Design of Induction Motors with Examples from Recent European Practice. H. M. Hobart. Shows the dependence of the factor in Behrend's formula on the ratio of the length of the core to the pole pitch. 2500 w. Elec Wld & Engr—April 30, 1904. No. 62550.

TRANSMISSION.

High-Tension.

Some Experiences With High-Tension Transmission Lines. H. C. Reagan. Illustrates and describes experiences which have come under the observation of the writer. 1600 w. St Ry Rev—May 20, 1904. No. 62919 C.

Transformers.

Continuous-Current Transformers. J. W. Burleigh. Explains the method adopted by the writer for designing these machines, with remarks. Ills. 1500 w. Elec Engr, Lond—April 29, 1904. No. 62603 A.

The Elementary Principles of Transformer Design. Prof. Thomas Gray. Outlines a method of treatment which may be followed with advantage in making an original design. Deals mainly with the problem of maximum efficiency. 1800 w. Elec Wld & Engr—April 23, 1904. Serial. 1st part. No. 62454.

MISCELLANY.

Electrical Machinery.

Notes on the Design of Electrical Machinery. Louis Hunt. The first part of the paper deals with continuous-current machines, and the second part with alternating-current motors and generators. 2200 w. Mech Engr—April 23, 1904. Serial. 1st part. No. 62409 A.

We supply copies of these articles. See page 719.

Expositions.

Electricity at the Paris and St. Louis Expositions. Franz Welz. A comparison, showing the progress made in electricity during the four years since the Paris Exposition. Ills. 3800 w. Elec Wld & Engr—May 7, 1904. No. 62651.

Electrical and Mechanical Engineering in the Exposition Plant. J. R. Cravath. A summary of the work of the electrical and mechanical department of the Division of Works, which builds and operates the exposition. Ills. 1600 w. Elec Wld & Engr—May 7, 1904. No. 62652.

Wind Vane.

Electrically-Registering Wind Vane and Anemometer for School Use. H. W. Harmon. Illustrated description of devices for weather work used in teaching physics. 1600 w. Sci Am Sup—May 14, 1904. No. 62657.

GAS WORKS ENGINEERING

Acetylene.

Acetylene in German Villages. Information concerning consumption, price, success, &c. 1200 w. Engr, Lond—May 13, 1904. No. 62776 A.

Benches.

The Construction and Operation of Recuperative Benches No. II. W. A. Baehr. A discussion of the practical and important considerations of the materials of bench construction. Also general discussion. 15800 w. Pro Age—May 2, 1904. No. 62447.

Coke Breeze.

I. Burning Coke Breeze with Underfeed Stokers. N. E. Malone. II Burning Coke Breeze on Hollow Grates. C. H. Williams. Two papers read before the Ohio Gas Lgt. Assn. on the utilization of coke breeze as fuel. The first reports results of tests in Denver. The second reports a test at the gas plant of the Madison Gas & Electric Co. 4000 w. Pro Age—May 2, 1904. No. 62446.

Flow.

An Examination of Threlfall's Work on the Flow of Gases in Pipes. Discusses the investigations made and their application to the construction of a meter for the measurement of "Mond" gas. 2000 w. Jour Gas Lgt—April 19, 1904. No. 62392 A.

Fuel.

Gas as Fuel in Mechanical Heating Processes—Why the Dearer Fuel is Often the Best to Use. Edward P. Reichhelm. Presents reasons why gas blast-furnaces are economical. 1200 w. Am Mach—April 28, 1904. No. 62486.

Gasholder.

The Construction of a Large Modern Gasholder. Information from a paper by W. Doig Gibb on the new gasholder erected at St. Anthony's. Ills. 2500 w. Jour Gas Lgt—May 10, 1904. No. 62730 A.

Gas Plant.

The Development of the Modern Gas Plant. Thomas D. Miller. Read at meeting of Southwestern Gas, Electric and Street Railway Assn. Briefly reviews the history of the discovery of gas giving properties in coal, and the development, improvements, &c. 2500 w. Am Gas Lgt Jour—May 16, 1904. No. 62688.

Natural Gas.

Natural Gas History. F. H. Oliphant. From pamphlet issued by the U. S. Geol. Survey. An interesting review of the history of natural gas in the United States. 4000 w. Pro Age—May 16, 1904. No. 62684.

Oxide.

Economy in Oxide Purification. Henry L. Rice. Gives some results in purification at the Norfolk, Va., works. 2000 w. Gas Engrs' Mag—May 10, 1904. No. 62729 A.

Photometry.

Mr. Jacques Abady on "Photometry." A lecture on photometry in relation to gas testing. 8000 w. Jour Gas Lgt—May 3, 1904. No. 62713 A.

Pressure.

Some Thoughts on the Regulation of Pressure. Thomas Glover. Read before the E. Co.'s Gas Mgrs.' Assn. Abstract. Gives the writer's experience in exhausting gas from retorts under somewhat unusual conditions, and discusses regulation of pressure. General discussion. 3500 w. Gas Wld—April 23, 1904. No. 62406 A.

Price.

A Plea for One Price. Norton H. Humphreys. Suggesting that the price be given in plain figures and all discounts and financial accommodation stated as a separate transaction. 1500 w. Jour Gas Lgt—May 3, 1904. No. 62712 A.

Producer.

Deschamp's Down-draft Gas Producer. An illustrated description with report of tests. 3800 w. Ir & Coal Trds Rev—May 13, 1904. No. 62953 A.

Retorts.

Horizontal v. Inclined Retort Installations, with Notes on Coke Conveying. J. G. Newbigging. Read before the Manchester Dist. Inst. of Gas Engrs. Considers the costs of the two systems, the

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durability, production, &c., describing work undertaken by the writer, and giving information of interest. 4300 w. Gas Engrs' Mag—May 10, 1904. No. 62728 A.

The Mechanical Operation of a Gas Retort House (La Manutention Mécanique dans l'Atelier de Distillation d'une Usine à Gaz). A. Thibeault. A very complete account of recent methods of mechanically charging and drawing gas retorts, both horizontal and inclined. Three articles. 9000 w. 3 plates. Génie Civil—April 16, 23, 30, 1904. No. 62811 each D.

Tynemouth.

Recent Extensions, Etc., at the Tynemouth Gasworks, North Shields. A. Clement Hovey. Read before the N. of England Gas. Mgrs.' Assn. A report of recent extensions and working results with discussion. 7000 w. Gas Wld—May 7, 1904. No. 62708 A.

Water Gas.

Leading Water Gas Through Coal Gas Retorts. Herr Croissant. Summary of an address before the Mid-Rhine Dist. Assn. A record of experiments and conclusions. 1600 w. Gas Wld—May 14 1904. No. 62765 A.

Works.

A Study of Some American Gas-Works. A. J. Walker. Comments on things seen and heard during a recent visit to the United States and Canada. 1600 w. Jour Gas Lgt—May 3, 1904. Serial. 1st part. No. 62711 A.

INDUSTRIAL ECONOMY

Apprentices.

The Apprenticeship Systems of the Baldwin Locomotive Works. S. M. Vauclain. An authoritative account of the successful apprentice systems of the great locomotive works in Philadelphia. 3000 w. Engineering Magazine—June, 1904. No. 62880 B.

Chemical Engineer.

The Chemical Engineer. Report of a paper by J. B. F. Herreshoff, and of the discussion. Deals with the training of a chemical engineer. 3200 w. Electro-Chem Ind—May, 1904. No. 62644 C.

Compensation.

Five Years' Experience of the Effect of the Workmen's Compensation Acts. William H. Tozer. Abstract of a paper read before the Royal Statistical Soc. A review with the inference that the Acts have been beneficial to the working classes. 5000 w. Ir & Coal Trds Rev—April 22, 1904. No. 62476 A.

Cost Keeping.

Pattern Costs. R. W. MacDowell. Explains a system of keeping accurate costs of patterns, giving forms used. 1500 w. Ir Trd Rev—May 5, 1004. No. 62544.

Education.

Technical Education: London and Birmingham. C. Alfred Smith. Explains the systems to be given a trial at these two cities. The systems are entirely different, under almost similar conditions. 1400 w. Elec Rev, Lond—April 22, 1904. No. 62411 A.

The Education of the American Electrical Engineer. Prof. W. E. Ayrton. Reprint from the "Mosely Ed Com. Report." Information gathered during the recent visit to the United States. 3000 w. Elec Engr, Lond—April 22, 1904. Serial. 1st part. No. 62410 A.

Engineers.

The Relation of the Engineer to Finance. An address at the Univ. of Illinois by John W. Alvord. 2800 w. Eng Rec—May 21, 1904. Serial. 1st part. No. 62759.

Labor.

The Evil and the Good of Labor Unions. Address of Charles S. Mellen. (Abstract.) A notable address to a gathering of the employees of the New York, New Haven & Hartford railroad. 2000 w. Ry Age—May 6, 1904. No. 62560.

The Union Movement Among Coal-Mine Workers. Frank Julian Warne. A study of the trade union movement among the coal mine workers, pointing out the causes of the successes and failures marking its growth. 16800 w. Bul Bureau of Labor—March, 1904. No. 62467 D.

Laboratories.

The Engineering Laboratories at the South-Western Polytechnic, London. An illustrated detailed description of laboratories and their equipment for the instruction of students. 8700 w. Mech Engr—May 7, 1904. No. 62709 A.

The Equipment of a Laboratory for Metallurgical Chemistry in a Technical School. Charles H. White. States the principles to be observed in the equipment, and gives an illustrated description of the laboratory for metallurgical chemistry at Harvard University. 1400 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62933.

Premium System.

A Premium Plan of Wage Payment in a Repair Shop. A. W. Thompson. De-

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scribing the successful adaptation of the premium system to a drop having no fixed product. 2500 w. Engineering Magazine —June, 1904. No. 62882 B.

Rules.

Union Rules Submitted to the Atchison. Extracts from a proposed set of rules, with comments by J. W. Kendrick. 1700 w. R R Gaz—May 13, 1904. No. 62669.

St. Louis Exposition.

The International Exhibition at St. Louis, U. S. A. The present article is introductory to a description of this great enterprise, with remarks on the construction work. 2500 w. Engr, Lond—May 6, 1904. Serial. 1st part. No. 62724 A.

The Engineering Characteristics of St. Louis. The first of a series of articles, giving illustrated descriptions of engineering features of the city likely to be of interest to foreign visitors. 4000 w. Engr, Lond—April 22, 1904. No. 62424 A.

South Africa.

South Africa and Her Labor Problem. Charles Sydney Goldmann. Discusses present conditions in South Africa and the great need of labor, the remedy, &c. 7000 w. Nineteenth Cent—May, 1904. No. 62694 D.

Timing.

Estimating Time for Lathe Work. Henry Hess. Considers methods of estimating in use, giving charts. 3000 w. Mach, N. Y.—May, 1904. No. 62545 C.

Wage Methods.

Wage-Paying Methods from the Viewpoint of Invested Capital. Henry Hess. Mr. Hess's concluding paper gives a graphic study of the effects of various methods upon the funds used and the dividends paid. 3500 w. Engineering Magazine—June, 1904. No. 62887 B.

Wages.

A Rational Basis for Wages. Harrington Emerson. An interesting contribution to the labor problem, and the relations of the employer and employee, with especial reference to the development of the interested co-operation of the latter. 4800 w. Trans Am Soc of Mech Engrs, No. 022—June, 1904. No. 62905.

Works Management.

Staff and Departmental Organization. Hugo Diemer. Remarks on the advantages of organization, and suggestions for making a study of the system best suited to the factory. 1800 w. Ir Trd Rev—May 5, 1904. No. 62543.

MARINE AND NAVAL ENGINEERING

Boilers.

See Mechanical Engineering, Steam Engineering.

Cargo Handling.

Some Modern Quayside Cargo Appliances. Brysson Cunningham. Briefly reviews the modern systems of handling coal, grain, ore, oil, timber and other cargoes. Ills. 3500 w. Cassier's Mag—May, 1904. Serial. 1st part. No. 62781 B.

Cruiser.

Trial Trip of the U. S. Protected Cruiser Tacoma. Illustration, with description of the vessel and its machinery and report of trial. 1000 w. Marine Engng—May, 1904. No. 62460 C.

Ferryboat.

A New Southern Ferryboat. Illustrates and describes a wooden-hull screw ferry boat now under construction in Florida. 600 w. Naut Gaz—April 28, 1904. No. 62448.

Pacific Coast Ferryboat. Illustrated description of the Ramona, built for service in Southern California. 700 w. Naut Gaz—May 12, 1904. No. 62643.

Fire Prevention.

Fire Prevention on Board Ship. Edwin O. Sachs. Read before the Inst. of Naval Archts. Considers safeguards of construction and equipment, administrative arrangements, fire extinguishing, &c. 4500 w. Engng—May 6, 1904. No. 62722 A.

Floating Workshop.

The Training of Engine-Room Artificers. Describes a new departure for fitting engine-room artificers for the Royal Navy. An extensive floating department strictly under naval discipline. Ills. 2400 w. Engng—April 22, 1904. No. 62418 A.

The Training of Engine-Room Artificers for the Royal Navy. Illustrated description of the training ship Bellerophon to be used in fitting mechanics for the Royal Navy. 2500 w. Engr, Lond—April 22, 1904. No. 62425 A.

Ice-Breaker.

The Russian Ice-Breaker "Ermack." Illustrated description of the ice-breaking steamer designed by Admiral Makaroff. 1300 w. Sci Am—May 7, 1904. No. 62589.

Integraph.

The Uses of the Integraph in Ship Calculations. John G. Johnstone. A short description of the nature of the work of

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the integraph, and how it can be applied to calculations relating to a vessel's form. Also a short description of the machine and the properties of integral curves. Plate. 4000 w. Trans Inst of Engrs & Shipbuilders in Scotland—March 22, 1904. No. 62430 D.

Lake Steamer.

Steamer Augustus B. Wolvin of the Great Lakes. An illustrated description of the largest vessel ever built to navigate fresh waters. 1200 w. Marine Engng —May, 1904. No. 62462 C.

Life Saving.

Donvig's Life-Saving Globe. An illustrated description of this life-saving device, with reports of trials. 600 w. U S Cons Repts—May, 1904. No. 62428 D.

Lighthouse.

The Mile Rock Steel and Concrete Lighthouse, California. Illustrated detailed description. 1500 w. Eng Rec—May 14, 1904. No. 62677.

Merchant Marine.

German Merchant Marine. Reviews the history and development, describing the character of the German shipping and giving much information. 6000 w. U S Cons Repts—May, 1904. No. 62427 D.

The Merchant Marine (La Marine Marchande). Marcel Plessix. The first installment of a serial devoted to the development of merchant vessels and their influence upon international trade. Serial. Part I. 2000 w. Revue Technique —April 10, 1904. No. 62814 D.

Motor Boats.

How to Build a Power Dory. C. D. Mower. Drawings and description. 2200 w. Rudder—May, 1904. No. 62470 C.

Motor-Boat Hull Experiments. Illustrated account of a series of tests made with full-sized models for Napier boats. 700 w. Auto Jour—April 23, 1904. No. 62399 A.

New Power Boats. C. D. Mower. An illustrated article giving much information in regard to these boats, the different designs, &c. 3800 w. Rudder—May, 1904. No. 62469 C.

Oil-Burning.

12,726-Mile Run of the Nebraskan Burning Oil. An account of the run from San Diego to New York, steaming with oil fuel. Illustrates and describes the machinery, oil-burning system, operation, performance, &c. 2000 w. Marine Engng —May, 1904. No. 62459 C.

Painting.

Redman's System for Cleaning and Painting Ships. Illustrated description of a mechanical process, with statement of advantages. 1200 w. Engng—May 6, 1904. No. 62718 A.

Resistance.

Some Results of Model Experiments. R. E. Froude. A description of general experiments on systematic variations in form of hull, with results. 3700 w. Engr, Lond—May 6, 1904. No. 62727 A.

Scouts.

Sea Scouting. Editorial explaining the importance of these vessels, their use in warfare, and the requirements. 2800 w. Engng—April 22, 1904. No. 62421 A.

Screw Propellers.

The Problem of the Screw Propeller. John Lowe. An explanation of the writer's theory and calculations, testing by example. 2000 w. Sci Am Sup—May 28, 1904. No. 62960.

Steamships.

Steamship Design. Carl C. Thomas. A general description of the operations involved in designing vessels and their machinery. 4000 w. Cal Jour of Tech—May, 1904. No. 62624 C.

Steamship Service.

Trans-Atlantic Steamships. Reviews briefly the history of steam navigation on the Atlantic, giving an idea of the immense amount of money invested, the cost of a single passage for the large liners, and much interesting information. Ills. 5700 w. Naut Gaz—May 5, 1904. No. 62541.

Strength.

The Transverse Strength of Ships. J. Bruhn. Read before the Inst. of Naval Archts. Applies the method of least work to show the effect on the strength, of variations in the method of construction, or in the arrangement of the support and loading of ordinary cargo vessels. Ills. 4700 w. Engng—April 22, 1904. No. 62422 A.

Torpedoes.

Torpedoes and Torpedo Warfare. Hudson Maxim. An account of the present state of the torpedo art, showing the advantage of greatly increasing the speed and range of the Whitehead torpedo. Ills. 4000 w. Rev of Revs—May, 1904. No. 62431 C.

Yachts.

H. H. Rogers' Steam Yach Kanawha. Illustrates and describes the vessel that holds the record as the fastest cruising steam yacht in America. 3500 w. Marine Rev—May 5, 1904. No. 62537.

Japanese Imperial Yacht Hatsukaze. Illustrated detailed description of the yacht and its equipment. 1800 w. Marine Engng—May, 1904. N. 62458 C.

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MECHANICAL ENGINEERING

AUTOMOBILES.

Automobile Trains.

Continuously - Propelled Automobile Trains. Emile Guarini. An illustrated description of the Renard train and its operation. 1000 w. Sci Am Sup—May 14, 1904. No. 62655.

Auto Truck.

The Torbensen Gear Gasoline Auto Truck. An illustrated description of a truck for business uses. 1500 w. Ir Age—May 5, 1904. No. 62515.

Commercial Vehicles.

The Inwardness of Automobilism. M. C. Krarup. An examination of the deficiencies of present machines, deprecating the fact that pleasure vehicles have turned attention away from permanent improvements. The importance of better tires and fuels is emphasized. 4000 w. Iron Age—May 5, 1904. No. 62517.

Cooling.

The Cooling of Explosive Motors on Automobiles. J. Grouvelle and H. Arquembourg. States the causes that may increase or diminish the amount of heat absorbed by the cylinder wall, and discusses methods of getting rid of the heat. 2800 w. Mech Engr—April 30, 1904. No. 62602 A.

Electric Vehicles.

Electricity as a Motive Power for Automobiles. H. W. Alden. A lecture before the Boston Y. M. C. A. Discusses the importance of care and intelligent operation, cost, &c. 2000 w. Sci Am Sup—May 7, 1904. No. 62591.

Engines.

Compound Engine of the White Steam Car. Illustrated detailed description. 1000 w. Am Mach—May 26, 1904. No. 62955.

The Gasoline Engine as Applied to Automobiles. Albert L. Clough. Lecture before the Boston Y. M. C. A. Automobile School. Discusses the requirements. Ill. 4000 w. Mech Engr—May 14, 1904. No. 62768 A.

Engine Speeds.

Cylinder Dimensions and Engine Speeds Compared. J. W. Roebuck. Discusses the speed of motors, single cylinders, the ratio of bore to stroke, &c. 1400 w. Autocar—April 23, 1904. No. 62405 A.

Gasoline Cars.

Suggestions to the Inexperienced. A. D. River. A discussion of the principles of the gasoline car for the benefit of novices. Ills. 2400 w. Automobile—May 14, 1904. Serial. 1st part. No. 62686.

Ignition.

Ignition of Gasoline Motors. R. L. Hubler. Briefly describes obsolete methods of ignition and explains electric spark ignition, the generation and application of the current, &c. Ills. 4500 w. Marine Rev—May 5, 1904. No. 62538.

The Ignition or Induction Coil Explained. Illustrated description of the component parts and the action of the cell. 1600 w. Autocar—May 7, 1904. No. 62706 A.

Law.

Provisions of New York Automobile Law. A summary of the new license requirements with the advantages claimed, and complete text of the Hill Automobile Law. 4800 w. Automobile—May 14, 1904. No. 62687.

Locomotive.

A Powerful Gasoline Locomotive. Illustrated description of a gasoline motor for hauling freight cars across London. 600 w. Sci Am Sup—May 7, 1904. No. 62592.

Military.

Motor Cycles for Military Purposes. Lieut. H. G. de Watteville. A discussion of the advantages and disadvantages of motor cycles for scouting purposes, examining details of construction rendering them applicable for military service. 3500 w. Jour Unit Serv Inst—March 15, 1904. No. 62451 D.

Motor Cars.

Motor Cars. Alexander Govan. Deals with the various parts of the motor car from the time it commenced to be adopted for every day use, considering principally petrol-driven vehicles. 4 plates. 8500 w. Trans Inst of Engrs & Shipbldrs in Scotland—April 26, 1904. No. 62620 D.

Popular Motor Cars. Mervyn O'Gorman. Discusses devices used on motor cars, popular prejudices, &c., and urges that some discarded devices be reconsidered. General discussion. 6000 w. Jour Soc of Arts—April 22, 1904. No. 62404 A.

The Accessories of a Motor Car. Lieut. W. Windham. Describes the different parts of a motor car which are essential to its complement, but which are usually left to the buyers' choice. Gives what the writer considers the best, with reasons. 1300 w. Autocar—April 30, 1904. Serial. 1st part. No. 62598 A.

Napier.

The Napier Motor Car and Petrol Launch. An illustrated description of the petrol engine made to actuate motor cars and small vessels. 3700 w. Engng—April 22, 1904. No. 62417 A.

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Petrol Car.

The 24-H. P. "Automotor" Petrol Car. Illustrated description of a fast touring car of the chain-driven type. 1500 w. Auto Jour—April 30, 1904. No. 62600 A.

Railway Automobiles.

Rail-Autocar for the Paris, Lyons, and Mediterranean Railway. Illustrated description of the design of the motor-car adopted by this road. 500 w. Engng—May 6, 1904. No. 62716 A.

Steam Automobiles for Railway Service (Nouvelles Voitures Automobiles à Vapeur pour Voies Ferrées). F. Barbier. Illustrating and describing a number of special and inspection cars for use in minor service on steam railways in France and England. 3000 w. 1 plate. Génie Civil—April 9, 1904. No. 62810 D.

The Petrol Electric Cars for the North Eastern Railway. Brief illustrated description. 800 w. Engng—April 22, 1904. No. 62419 A.

Renault.

The New 14 H. P. Renault. Illustrated description dealing principally with a novel arrangement of the water-cooling system, in this case of the natural or thermo-syphon type. 600 w. Autocar—April 30, 1904. No. 62597 A.

Silencers.

Design of Silencers. Rudolph E. von Lengerke. Describes a silencer of the writer's design giving his theories. Ill. 2500 w. Autocar—May 14, 1904. No. 62763 A.

Steering Gears.

Steering Gears for Motor Cars. C. H. Gale. On properly designing steering gear, giving tables, curves, and explanatory notes. 2000 w. Auto Jour—April 23, 1904. No. 62400 A.

Tyre Pumps.

The Automatic Tyre Pump — the "Pompeesi." Illustrated description of the apparatus and its operation. 800 w. Auto Jour—April 30, 1904. No. 62601 A.

Voiturettes.

The 6½-H.-P. Baby Peugeot. Illustrates and describes the 1904 model. 1600 w. Auto Jour—April 30, 1904. No. 62599 A.

The Wolseley 6-H. P. Voiturette. Illustrated detailed description. 1200 w. Auto Jour—May 7, 1904. Serial. 1st part. No. 62707 A.

HEATING AND COOLING.

Buildings.

Heating and Ventilation of Buildings. R. C. Carpenter. Read before the Ohio Archt's Assn. Considers temperature required, effect of moisture, need of ventilation, various systems, &c. 3000 w. Dom Engng—April 25, 1904. No. 62445 C.

Capitol.

Heating and Ventilating the Minnesota State Capitol. Illustrates and describes an interesting plant on the plenum system. 3700 w. Eng Rec—May 21, 1904. No. 62758.

Cooling Plant.

Cooling Plant in Cologne Theater. Joseph Musmacher. Describes the refrigerating plant in a new city theater in Germany, in which heating, cooling and ventilating are all through the same conduits. Ills. 2400 w. Ice & Refrig—May, 1904. No. 62449 C.

Ice Machines.

Ice Machine Parts. T. R. Wingrove. Remarks on the need of attention to the parts in the erection of ice making plant, atmospheric condensers, purging oil out of condenser connections, &c. Ill. 2800 w. Ice & Refrig—May, 1904. No. 62450 C.

Office Building.

Heating and Ventilating a Works Office Building. Illustrated description of the plant installed for the administration building of the American Bridge Company at Ambridge, Pa., as an example of good practice. 2800 w. Eng Rec—May 14, 1904. No. 62679.

Refrigeration.

Mechanical Refrigeration of Freight Cars. Warren H. Miller. An illustrated description of the Miller system in which carbon-dioxide gas is used as the refrigerating medium. 2500 w. Stevens Ind—April, 1904. No. 62432 D.

Systems and Methods of Mechanical Refrigeration. Sterling H. Bunnell. A general review of the various methods of producing artificial cold, discussing details of practical construction and operation. 5000 w. Engineering Magazine—June, 1904. No. 62886 B.

The Common Systems of Mechanical Refrigeration. Sterling H. Bunnell. Explains the distinctive points of the various systems. 2500 w. Engr, U S A—May, 1904. No. 62698 C.

Regulation.

The Regulation of Low Pressure Steam Heating (Die Generelle Regelung der Niederdruckdampfheizung). F. Gremmels. A description of the use of throttling tubes for reducing steam pressure. 3000 w. Gesundheits-Ingenieur—April 20, 1904. No. 62870 B.

Ventilation.

Air and the Ventilation of Dwellings (Ueber Luft und Lüftung der Wohnung und Verwandte Fragen). Th. Oehmcke. A general discussion of the effect of impure air upon health and of the best methods of ventilation and the removal of dust. 8000 w. Gesundheits-Ingenieur—May 10, 1904. No. 62872 B.

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The Humidification and Ventilation of Factories (L'Humidification et la Ventilation des Ateliers). Paul Razons. Describing various devices for supplying textile factories with air containing a predetermined amount of moisture. Two articles. 3000 w. Génie Civil—April 16, 23, 1904. No. 62812 each D.

HYDRAULICS.

Flow.

A Chemical Method of Measuring Water Flow (Methode Chemique pour la Mesure du Débit des Conduites d'Eau). F. van Iterson. The process consists in delivering a known volume of a solution of hyposulphite of soda into the suction of the pump, and analyzing the strength of the diluted discharge. 1000 w. Génie Civil—April 30, 1904. No. 62813 D.

Impulse Wheel.

Efficiency Test of an Impulse Wheel. Joseph N. Le Conte. An outline of the machinery used, the methods employed, and the preliminary results obtained, in the tests of a 3-foot impulse water wheel. Ills. 1800 w. Cal Jour of Tech—May, 1904. No. 62622 C.

Pumping Engines.

Some Recent Pumping Engine Tests. Frank A. Whitten. Brief description of the recent addition to the water supply of Chicago, with report of tests. 3000 w. Eng News—May 26, 1904. No. 62962.

Pumps.

The Use and Abuse of Direct Acting Steam Pumps. W. H. Wakeman. An illustrated article giving suggestions. 1700 w. Power—May, 1904. No. 62480 C.

INTERNAL-COMBUSTION MOTORS.

Alcohol.

The Need of Duty-Free Spirit for Industrial Purposes. Thomas Tyrer. A vast amount of information in regard to the manufacture, use, and duty on alcohol. General discussion. Refers to England principally. 27000 w. Jour Soc of Arts—April 29, 1904. No. 62594 A.

The Present Status of Alcohol in Technology (Ueber den Gegenwärtigen Stand der Technischen Spiritusverwertung). Dr. N. Wender. Giving statistics as to the production of alcohol in various parts of Europe, discussing its extending use as a fuel. Two articles. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—April 8, 15, 1904. No. 62822 each D.

Gas Power.

Power from Coke-Oven Gases (Die Verwertung des Koksofengases). H. Baum. An exhaustive discussion of the composition, purification and utilization of the waste gases from coke ovens; with details of construction of ovens, purifiers and large gas engines. Serial. Part I. 5000 w. Glückauf—April 16, 1904. No. 62845 B.

Indicator Diagrams.

The Indicator Diagram of a High-Speed Petrol Motor. Prof. H. L. Callendar. Read before the Auto-Cycle Club, So. Kensington. Describes the method adopted for obtaining high-speed indicator diagrams, showing how the indicator may be utilized in the study of the theory of the motor, and as a guide to its practical improvement. 3000 w. Auto Jour—May 14, 1904. No. 62764 A.

Marine Work.

The Internal-Combustion Engine as a Means of Propelling Small Vessels. Arthur F. Evans. Read before the Inst. of Naval Archts. Reviews the various applications of motors to the propulsion of small vessels, and discusses the designs and development. 5700 w. Prac Engr—May 13, 1904. No. 62766 A.

Motors.

Internal Combustion Motors. Dugald Clerk. Abstract of a lecture before the Inst. of Civ. Engrs. Notes briefly what has been accomplished and discusses what remains to be done in the development of internal combustion motors. 2000 w. Engr, Lond—April 22, 1904. Serial. 1st part. No. 62426 A.

Testing.

Commercial Gas Engine Testing and Proposed Standard of Comparison. William P. Flint. Explains the value of the friction brake as a satisfactory means of measuring the power developed, describing the system of plotting the results of tests. Ills. 2500 w. Trans Am Soc of Mech Engrs, No. 032—June, 1904. No. 62910.

MACHINE WORKS AND FOUNDRIES.

Castings.

Green Sand Bottoms and Sound Castings. Suggestions and opinions in regard to molding. 1400 w. Foundry—May, 1904. No. 62439.

Some Zinc Alloys for Castings. Walter J. May. Information concerning alloys found useful for a variety of purposes. 800 w. Prac Engr—April 22, 1904. No. 62408 A.

The Casting of the Williamsburg Bridge Entablatures—A Notable Technical Achievement. Illustrations, with brief description of the casting of tablets 52 feet 7 inches long and 4 feet 3 inches wide. 800 w. Sci Am—May 28, 1904. No. 62959.

The Need of Standard Specifications for Gray-Iron Castings. Henry Souther. Discusses the proposed specifications, giving reports of tests of material made as directed, and information concerning the castings. 3500 w. Trans Am Inst of Min

The Influence of Varying Casting Temperature on the Properties of Steel and Iron Castings. Percy Longmuir. Experi-

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mental work in which all conditions other than temperature are identical, the results showing the influence of varying casting Engrs—Feb., 1904. No. 62935.
temperature. 3200 w. Ir & Coal Trds Rev —May 6, 1904. No. 62740 A.

Crucibles.

Some Uses for Old Crucibles. J. F. Buchanan. Remarks on the treatment of crucibles, with suggestions for their profitable use when old. 1700 w. Foundry—May, 1904. No. 62440.

Cupolas.

The Effect of Limestone Additions on the Product in Cupola Practice, According to the Researches of A. Sulzer-Grossman, Winterthur. Edited by F. Wust. Translated by J. E. Johnson, Jr. An account of investigations. 2000 w. Am Mach—May 12, 1904. Serial. 1st part. No. 62586.

Dies.

An Automatic Push Feed and Gang Die. Jack Marks. Illustrates and describes an automatic die for making a scalloped cap of 1C tin. 900 w. Am Mach—May 5, 1904. No. 62547.

Electro-Magnets.

Practical Applications of Electro-Magnets in the Modern Machine Shop, Iron and Steel Works and Shipyard. Frank C. Perkins. Illustrated descriptions of electro-magnetic machines, their uses, types, &c. 2,000 w. Mod Mach—May, 1904. No. 62468.

Foundry.

Foundry of the American Locomotive Works, Schenectady, N. Y. An illustrated detailed description of an interesting plant. 1500 w. Foundry—May, 1904. No. 62438.

Jig.

The Hancock Jig. F. Danvers Power. Illustrated description of a jig of the reciprocating screen type, which has been largely used for treating ores of copper and lead in Australia. 1000 w. Eng & Min Jour—May 19, 1904. No. 62751.

Lathes.

Facing Pipe Flanges in the Field—An Improvised But Very Efficient Lathe. E. L. Mills. Illustrates and describes the facing of the flanges of thirty-four pieces of pipe in connection with work on the N. Y. aqueduct. 1000 w. Am Mach—April 28, 1904. No. 62484.

Lathe Spindle.

Bench Lathe Cone Spindle and Box Fitting. Detailed Account of a Delicate Piece of Work. John Randol. An illustrated description of spindle and box grinding. 2500 w. Am Mach—May 12, 1904. No. 62587.

Machine Tools.

Some Early Machine Tools. Calls attention to early contrivances devised to relieve hand labor. Ills. 3300 w. Engr, Lond—May 6, 1904. Serial. 1st part. No. 62723 A.

Specifications for Machine Tools. An account of the practice of various companies, giving examples. 2000 w. Eng News —May 12, 1904. No. 62666.

Milling.

A Milling Operation in a New York Shop. An illustrated description of work performed in a lathe instead of in a miller, showing the efficiency of the arrangement. 1000 w. Am Mach—May 5, 1904. No. 62546.

Pittsburg.

Frank-Kneeland Plant of the United Engineering & Foundry Co. Illustrated detailed description of the Pittsburg plant of this company, which is located at the foot of 56th street. 3500 w. Ir Trd Rev—May 5, 1904. No. 62542.

St. Louis Exposition.

The World's Fair Machinery Display. Lieut. G. L. Carden. Calls attention to notable exhibits and features of interest. Ills. 2300 w. Elec Wld & Engr—May 7, 1904. No. 62653.

Shear Blades.

Designing, Fitting and Tempering Shear Blades. T. Foot. An illustrated article showing the proper design of shear blades and their fittings for easy setting and adjustment. 1800 w. Am Mach—May 5, 1904. No. 62548.

Specifications.

Chemical Specifications for Pig-Iron. Edgar S. Cook. On the grading by chemical analysis and the difficulties besetting the accurate determination of the composition of sand-cast pig. Also discussion. 4500 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62934.

Steel Belts.

The Locke Steel Belt Machine. Illustrated description of a machine for automatically manufacturing steel sprocket chains. 2500 w. Ir Age—May 12, 1904. No. 62588.

Steel Foundry.

Hadfield's Steel Foundry, Sheffield. A brief description of the largest steel foundry in the world, covering 6 acres. 1600 w. Col Guard—April 22, 1904. No. 62-415 A.

Tool Making.

Diamond Dust for Laps and Sapphires for Cutting Tools. Joseph M. Stabel. Information, with illustrations, of the use of these precious stones in the making of small tools of precision. 1500 w. Am Mach —May 26, 1904. No. 62956.

Wheels.

The Manufacture of Hydraulically Forged and Rolled Solid Steel Railway

We supply copies of these articles. See page 719.

Wheels. Henrik V. von Z. Loss. An illustrated description of the process used in the manufacture of wheels for steel cars, with much information related. 4700 w. Jour Fr Inst—May, 1904. No. 62629 D.

MATERIALS OF CONSTRUCTION.

Alloys.

Alloys of Copper and Arsenic. Arthur H. Hiorns. Experiments made to ascertain the exact relation between copper and arsenic in binary alloys, and the limit of proportion of arsenic that can be retained in copper in the cold solid state. Ills. 2800 w. Elec-Chem & Met—April, 1904. No. 62630 C.

Imperfect Equilibrium in Alloys. F. Osmond. An illustrated study. 1800 w. Ir & Steel Mag—May, 1904. No. 62638 D.

The Range of Solidification and the Critical Ranges of Iron-Carbon Alloys. H. C. H. Carpenter and B. F. E. Keeling. Researches testing the accuracy of conclusions reached in the paper by Prof. Bakhuis-Roozeboom. 2500 w. Ir & Coal Trds Rev—May 6, 1904. No. 62736 A.

Asbestos.

Asbestos and Its Uses. An illustrated description of asbestos from the raw material to the finished article, giving much information. 3000 w. Elec Rev, Lond—April 29, 1904. No. 62607 A.

Asbestos and Its Uses in Engineering. A. Leonard Summers. An illustrated article noting some of the more important uses made of this material in electrical and mechanical engineering. 1000 w. Prac Engr—May 13, 1904. No. 62767 A.

Metallography.

Microscopic Metallographv (La Métallographie Microscopique). G. Cartand. The first installment of a serial treating of the development of the use of the microscope for the study of the physical structure of metals. Serial. Part I. 2000 w. Revue Technique—April 10, 1904. No. 62814 D.

Plastic Strain

The Plastic Yielding of Iron and Steel. Walter Rosenhain. Read before the Iron & Steel Inst. A re-examination of evidence, because of disagreement of French authors with results, and the new developments. Ills. 4500 w. Ir & Coal Trds Rev—May 6, 1904. No. 62737 A.

Steel.

Notes on Rail-Steel. Robert W. Hunt. On the importance of the mechanical treatment of the metal forming a steel rail, during its manufacture. 1500 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62940.

Sorbitic Steel. H. C. Bovnton. An illustrated report of experimental researches, stating results. 2000 w. Ir & Steel Mag—May, 1904. No. 62637 D.

Stresses.

On the Relations Between the Effects of Stresses Slowly Applied and of Stresses Suddenly Applied in the Case of Iron and Steel. Pierre Breuil. Abstract of a paper before the Iron & Steel Inst. Results of investigations are discussed. 2200 w. Ir & St Trds Jour—May 7, 1904. No. 62618 A.

Testing.

Typical English Testing Machines. A. Francis. Illustrates types of commercial patterns, and describes methods, showing the advantage to engineers in determining the strength of materials. 1500 w. Page's Mag—May, 1904. Serial. 1st part. No. 62779 B.

Tool Steels.

High Speed Tool Steel, Its Manufacture and Uses. J. M. Gledhill. Abstract of paper read before the Coventry Engng. Soc. Illustrates and describes the process of crucible cast steel, defining some of the substances used in its manufacture, and giving particulars of some of the alloys; also considers high-speed steel and its development. 5500 w. Ir & Coal Trds Rev—April 22, 1904. No. 62475 A.

Tungsten Steel.

Researches Upon Tungsten Steels (Recherches sur les Aciers au Tungstène). Léon Guillet. Data and results of a systematic study of tungsten steels, with microphotographs showing the effect of quenching and tempering. Serial. Part I. 1800 w. Génie Civil—May 7, 1904. No. 62827 D.

MEASUREMENT.

Dynamometer.

A New Device for Measuring the Power of Motors (Sur un Nouvel Appareil Destiné à la Mesure de la Puissance des Moteurs). Ch. Renard. The power of the motor is absorbed by the resistance of the air to the motion of vanes on the revolving shaft. The power is measured by the size of the vanes and the rotative speed. 1500 w. Comptes Rendus—May 2, 1904. No. 62839 D.

Pyrometry.

Notes on Pyrometry. M. E. J. Gheury. Read before the Arc Works Engng. Soc., Chelmsford, Eng. Reviews briefly the different methods used in measuring high temperatures, paying special attention to those adapted to industrial requirements. 5200 w. Engng—May 6, 1904. Serial. 1st part. No. 62721 A.

Speed Variations.

A Method for Rendering Speed Variations Visible (Ein Verfahren zur Sichtbarmachung Ungleich formigkeit bei Kraftmaschinen). Dr. P. Berkitz. The rotations of the engine shaft are compared with a uniformly rotating disc. 1000 w. Zeitschr

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f Elektrotechnik—April 17, 1904. No. 62868 D.

POWER AND TRANSMISSION.

Air Compressors.

Air Compressors and Blowing Engines. C. H. Innes. A mathematical demonstration of the work done in compressing air, illustrating by examples, is given in the present number. 2800 w. Prac Engr—April 22, 1904. Serial. 1st part. No. 62407 A.

Belts.

The Care and Management of Leather Belts. Walter E. Dixon. On the selection, care and management of belts. 2000 w. Power—May, 1904. No. 62479 C.

Bevel Gears.

Bevel Gears with Short Teeth. Robert A. Bruce. Gives proportions which apply to bevel wheels whose shafts are at right angles. 700 w. Am Mach—April 28, 1904. No. 62485.

Cone Pulleys.

Machining Cone Pulleys. Illustrates and describes the methods used at the works of the Lodge & Shipley Machine Tool Company. 600 w. Am Mach—May 12, 1904. No. 62585.

The Layout of Cone Pulleys. C. M. Sames. Mathematical demonstration. 500 w. Am Mach—May 19, 1904. No. 62747.

Conveying.

Balanced Cable Cranes for Handling Excavated Material at Devonport, England, and Zambesi Falls, South Africa. Describes the methods of excavation and the plants for handling materials. Ills. 1700 w. Eng News—May 12, 1904. No. 62665.

Cranes.

Modern Cranes (Neuere Krane). A. Müller. Illustrating improved gantry and titan cranes, of recent German design. Serial. Part I. 1500 w. Zeitschr d Ver Deutscher Ing—May 7, 1904. No. 62808 D.

Efficiency.

The Potential Efficiency of Prime Movers. C. V. Kerr. A discussion of waterwheels, steam engines, and steam turbines, reporting tests. 2500 w. Trans Am Soc of Mech Engrs, No. 030—June, 1904. No. 62908.

Inclined Elevator.

The Inclined Elevator at Weehawken, New Jersey. Illustrated description of an electrically operated elevator, designed primarily to lift loaded wagons from the shore roads along the Hudson River, to the heights above. 2800 w. Eng Rec—April 30, 1904. No. 62523.

Lifting Gin.

Electric Lifting Gins. Illustrates and describes an inexpensive and expeditious method of lifting locomotives for repairs. 2300 w. Transport—May 13, 1904. No. 62762 A.

Rope Driving.

Advantages of Rope Transmission in Textile Plants. Frederick S. Greene. Abstract of a paper read before the N. England Cotton Mfrs. Assn. Sums up the advantages as far as they apply to textile plants, giving a comparison of cost. 1500 w. Ir Age—May 5, 1904. No. 62518.

Ropes.

Wire Ropes. G. W. Westgarth. Abstract of a paper before the Nat. Assn. of Colliery Mgrs. Reviews briefly the history of wire ropes, and the varieties made. Ills. 5800 w. Ir & Coal Trds Rev—April 29, 1904. No. 62611 A.

Tall Buildings.

The Power Plant of the Tall Office Building. James Hollis Wells. Deals with the engineering problems that enter into the construction, the elevators, steam plant, electric plant and wiring, etc. Ills. 4500 w. Trans Am Soc of Mech Engrs, No. 023—June, 1904. No. 62906 C.

The Power Plant of Tall Office Buildings. Reginald Pelham Bolton. An illustrated article giving an interesting discussion of the elevator systems and service, heating and ventilation, water supply, lighting systems, &c., in the tall buildings of New York City. 5500 w. Trans Am Soc of Mech Engrs, No. 027—June, 1904. No. 62907 C.

Wind Power.

The Importance of Windmills from an Economic Viewpoint (Les Moteurs à Vent et leur Importance au Point de Vue Economique). W. Geutch. An extensive discussion of the construction and application of wind motors and their practical applications. Serial. Part I. 5000 w. Bull Soc d'Encour—April 30, 1904. No. 62848 G.

STEAM ENGINEERING.

Boilers.

Boiler Design. A discussion opened by R. H. Soule. 6300 w. Pro N. Y. R. R. Club—April 15, 1904. No. 62786.

The Management of Belleville Boilers at Sea. E. F. Baker. Gives the experience gained with these boilers on H. M. S. "Good Hope," and the treatment arising out of this experience, showing that by suitable treatment the Belleville boiler is satisfactory and economical. 7000 w. Engng—April 29, 1904. No. 62615 A.

Chimneys.

A Concrete-Steel Chimney Reinforced withT-Bars. Illustrates and describes a recently completed chimney at Zeigler, Ill., 154 feet 10 inches high, with an inside diameter of 6 feet. 800 w. Eng Rec—May 21, 1904. No. 62761.

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The Building of a 255-Foot Chimney. J. W. Buzzell. Gives an illustrated general description of the chimney, the method of construction, method of testing materials, and of supplying stock to the masons, &c. 3500 w. Engr, U S A—May 15, 1904. No. 62697 C.

Engine Erection.

Preparation for the Erection of an Engine. W. T. Edwards. Deals with the foundations, the anchor bolts, flywheels, the handling of the bed plate, &c. Ills. 3200 w. Am Elect'n—May, 1904. No. 62504.

Setting Up a Vertical Engine. John F. Nagle. Directions concerning the proper method. 1800 w. Power—May, 1904. No. 62482 C.

Engine Test.

Test of the Engines of the Rochester Gas and Electric Company. Illustrations of the station, with report of tests. 2000 w. Power—May, 1904. No. 62478 C.

"Flash" Steam.

"Flash" Steam Generating Systems. An explanation of the principles of construction and operation and details of well-known types. 3000 w. Automobile—April 30, 1904. Serial. 1st part. No. 62456.

Fuel Economy.

Fuel Economy in Steam Plants. John B. C. Kershaw. A discussion from the chemist's point of view, considering the fuel supply, the combustion, and the waste gases. 4300 w. Cassier's Mag—May, 1904. No. 62783 B.

Fuels.

On Fuel Formulas. Considers a formula proposed by Mahler for obtaining the heat value of fuels which is exact enough for most purposes. 2000 w. Locomotive—Nov., 1903. No. 62429.

Furnaces.

Furnace Fittings for Steam Boilers. R. T. Strohm. Considers the materials composing the furnace, the grates, and the appliances for aiding the process of combustion. Ills. 2800 w. Am Elect'n—June, 1904. No. 62972.

Heating Surface.

The Value of Heating Surface. H. H. Vaughan. A study of this subject in locomotive practice. with general discussion. 10,000 w. Pro W. Ry Club—April 19, 1904. No. 62785 C.

Horse-Power.

Horse-Power of Steam Engines. Irving A. Taylor. Gives a simple method of arriving at an approximate result in computing the power from the dimensions and other apparent data. 800 w. Elec Wld & Engr—April 23, 1904. No. 62453.

Measuring the Indicator Diagram and Computing the Horse-Power of an Engine. H. H. Kelley. Describes methods employed by engineers. Ills. 1700 w. Engr, U S A—May 1, 1904. No. 62506 C.

Induced Draught.

Ellis and Eaves' System of Induced Draught Applied to Marine Boilers. Illustrated description. 2300 w. Engng—May 6, 1904. No. 62717 A.

Piping.

Practical Notes on Steam Piping (Praktische Erfahrungen und Mitteilungen über Rohrleitungen). Max Westphal. An extensive discussion of pipes, pipe joints, expansion joints, and other details; also flow of steam in pipes, etc. 5000 w. Zeitschr d Ver Deutscher Ing—April 23, 1904. No. 62803 D.

Pounding.

Some Causes and Remedies for Pounding in Engines. W. E. Crane. Calls attention to errors that cause this trouble, and way to remedy. Ills. 1200 w. Power—May, 1904. No. 62481 C.

Pulverized Coal.

The Use of Pulverized Coal for Fuel Under Steam Boilers. J. M. Sweeney. Reviews the attempts made to use this fuel, discussing the degree of success, and concluding that it has not yet been proved satisfactory. General discussion. Ills. 9500 w. Jour W Soc of Engrs—April, 1904. No. 62642 D.

Recording Apparatus.

The Control of Furnace Combustion. Illustrates and describes the Krell-Schultze apparatus for determining the resulting carbon-dioxide and other quantities. Refers also to other systems. 2000 w. Engng—May 6, 1904. No. 62715 A.

Separators.

Oil Separators for Exhaust and Condensed Steam (Oelabscheider für Abdampf und Kondensationswasser). H. Kühl. Illustrating and describing various forms of filters and diaphragm separators for the removal of lubricating oil from discharge steam. 2000 w. Zeitschr d Ver Deutscher Ing—April 16, 1904. No. 62800 D.

Smoke Prevention.

Notes on Burning Bituminous Coal. John M. Hartman. A study of this subject with an account of investigations of the problem of preventing smoke. General discussion. 8200 w. Pro Engrs' Club of Phila—April, 1904. No. 62635 D.

Speed Regulation.

Steam Engine Speed Regulation. J. J. M'Guire. Explains the purpose of the governor, describing types. 1500 w. Am Elect'n—May, 1904. No. 62502.

Superheating.

Experiments for Determining the Spe-

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cific Heat of Superheated Steam. R. C. Carpenter. A report of experimental investigations and results. 2000 w. Sib Jour of Engng—May, 1904. No. 62913 C.

The Action of Superheated Steam in Reciprocating Engines (Das Verhalten Ueberhitzten Wasserdampfes in der Kolbenmaschine). Fritz Richter. Discussing tests on the experimental engine at Charlottenburg, including the calibration of instruments and graphical plotting of results. Three articles. 10,000 w. Zeitschr d Ver Deutscher Ing—April 30, May 7, 14, 1904. No. 62804 each D.

The Thermal Effect and the Practical Utility of Superheated Steam. Robert H. Smith. Discusses this subject, concluding the whole merit and utility of using superheated steam in engines lies in that it prevents condensation, and keeps the cylinder and ports dry. 2000 w. Elec Rev, Lond—May 13, 1904. No. 62769 A.

The Use of Superheated Steam and of Re-heaters in Compound Engines of Large Size. Lionel S. Marks. Gives results of 28 tests on 9 separate engines to determine the performance under different loads both with and without jacketing and reheating. Ills. 7500 w. Trans Am Soc of Mech Engrs, No. 021—June, 1904. No. 62904 D.

Traps.

Steam Traps. Walter W. Edwards. Illustrates and describes the various classes of steam traps according to their principle of operation. 2200 w. Engr, U S A—May 1, 1904. No. 62505 C.

Turbines.

Graphical Computations for the Steam Turbine (Die Berechnung der Dampfturbinen auf Zeichnerischer Grundlage). A. Koob. Showing the application of the temperature-entropy diagram to the practical problems of steam turbine design. Serial. Part I. 2500 w. Zeitschr d Ver Deutscher Ing—May 7, 1904. No. 62807 D.

Power Plant of the Yale & Towne Manufacturing Company. Illustrated description of a steam turbine installation in Stamford, Conn. 1200 w. Power—May, 1904. No. 62477 C.

The Parsons Steam Turbine (Der Parsons-Dampfturbine). Alfred Musil. Giving a historical review of the development of the Parsons turbine and an account of the latest construction; with especial reference to installations on the Continent. Two articles. 8000 w. Zeitschr d Oesterr Ing u Arch Ver—April 8, 15, 1904. No. 62823 each D.

Marine Steam Turbines. Reviews editorially the work already accomplished in adapting the steam turbine to marine use. 3000 w. Engng—May 6, 1904. No. 62720 A.

Multiple Impact Steam Turbine. A. M. Levin. Illustrates and describes a steam turbine of novel construction. 1000 w. Power—May, 1904. No. 62483 C.

New Steam Turbine Developments. W. L. R. Emmet. Confined principally to the work and experiences of the past year with the Curtis turbine. Gives the results of an interesting series of tests recently made upon one of the first of these turbines that was put into practical operation. 5000 w. Pro Engrs' Club of Phila —April, 1904. No. 62636 D.

Some Theoretical and Practical Considerations in Steam Turbine Work. Francis Hodgkinson. A discussion of special features of turbine work, which have a more or less intimate bearing upon the operation of a successful steam turbine. Considers types, giving illustrations, tests, &c. 10,000 w. Trans Am Soc of Mech Engrs, No. 031—June, 1904. No. 62909 D.

Steam Turbine Discs. Prof. Maurice F. FitzGerald. Discusses methods of calculating the stresses produced by rapid rotation in discs. 3500 w. Engr, Lond—May 13, 1904. No. 62774 A.

Tests of Steam Turbines at the Newport Station of the Old Colony Street Railway. A report of tests of Curtis turbines, with conclusions. 1000 w. Eng Rec—May 14, 1904. No. 62681.

The De Laval Steam Turbine. E. S. Lea, and E. Meden. An illustrated detailed description of the present type, with remarks on the difficult theoretical and practical problems encountered, the applications, &c. 3500 w. Trans Am Soc of Mech Engrs, No. 035—June, 1904. No. 62912.

The Steam Turbine. H. Boyd Brydon. An explanation of the laws under which the steam turbine operates, describing the principal types now on the market, the steam economy at present obtainable, and the applications of turbines as means of power production. 1600 w. Engr, U S A—May 15, 1904. Serial. 1st part. No. 62700.

The Steam Turbine. H. M. Gleason. Considers the advantages of the steam turbine over the reciprocating engine in general, and especially for the propulsion of ships. 1500 w. Sci Am Sup—April 30, 1904. No. 62536.

The Theory of Steam Turbines. Frank Foster. States the fundamental principles of turbines, describing briefly the different types, and considering the actions. Ills. 3000 w. Engng Rev—May, 1904. Serial. 1st part. No. 62957 B.

Vibrations.

The Vibrations of Crank Shafts (Schwingungen von Kurbelwellen). P. Roth. A mathematical investigation of the manner in which the forces upon engine shafts produce vibrations in the shaft; discussing especially a gas engine driving a dynamo. 2000 w. Zeitschr d Ver Deutscher Ing—April 16, 1904. No. 62801 D.

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MISCELLANY.

Kites.

Professor Bell and His Kites. Waldon Fawcett. An illustrated account of the experimental work of Prof. Alexander Graham Bell in the field of aerial navigation through the medium of kites. 900 w. Elec Rev, N. Y.—May 21, 1904. No. 62790.

Mechanics.

The Physical Results of Modern Technical Mechanics (Naturwissenschaftliche Ergebnisse der Neueren Technischen Mechanik). A. Sommerfeld. An address showing the extent to which engineering investigations upon the properties of materials have influenced the study of mechanical physics. 6000 w. Zeitschr d Ver Deutscher Ing—April 30, 1904. No. 62-805 D.

Observatory.

The Yerkes Observatory. Illustrates and describes this observatory, given the Univ. of Chicago, and located near William's Bay, Wisconsin. Deals with the mechanical details connected with the mounting and accessories. 2700 w. Engng—April 29, 1904. Serial. 1st part. No. 62613 A.

Sulphite Mill.

The Fenimore Sulphite Mill. Illustrated detailed description of a new plant of the Union Bag & Paper Company, near Sandy Hill, N. Y. 4500 w. Eng Rec—April 30, 1904. No. 62520.

Type-Composing.

Type-Composing and Distributing Machines. Illustrates and describes the Pulsometer Company's type-composing and justifying machine and a type-distributing machine. 2200 w. Engr, Lond—April 29, 1904. No. 62617 A.

MINING AND METALLURGY

COAL AND COKE.

Auchincloss.

The Auchincloss Colliery. Illustrated description of this new plant in the Wyoming-Lackawanna anthracite region. 2500 w. Eng & Min Jour—May 5, 1904. No. 62569.

Coal-Cutting.

British and American Coal-Cutting Machines. A. S. E. Ackermann. Abstract of a paper read before the Soc. of Engrs. Briefly reviews the history of these machines, describing British and American types, and giving statistics of interest. 5500 w. Ir & Coal Trds Rev—May 13, 1904. No. 62954 A.

Coal Mining.

The Ernest Plant of the Jefferson & Clearfield Coal & Iron Co., at Ernest, Indiana County, Pennsylvania. G. W. Harris. Illustrates and describes a development of coal properties exceeding in magnitude and originality anything hitherto attempted. 5000 w. Mines & Min—May, 1904. No. 62552 C.

Coke.

The Manufacture of Coke in the Hüssener Oven at the Clarence Ironworks, and Its Value in the Blast-furnace. C. Lowthian Bell. Read before the Iron & Steel Inst. Describes experiments made and the way the question of retort-oven coke was solved at Clarence, giving results. 4000 w. Ills. Ir & Coal Trds Rev—May 6, 1904. No. 62733 A.

Deep Mining.

The Application of Coal-Cutting Machines to Deep Mining. W. E. Garforth. Read at Nottingham Univ. College. An illustrated article comparing the method of working Longwall packgate by hand and by machine, stating the advantages and disadvantages and the qualifications a machine should possess. 6400 w. Ir & Coal Trds Rev—May 6, 1904. No. 62-741 A.

Explosion.

The Harwick Mine Explosion. Report to the Commissioner of Mines by Board of Mine Inspectors who investigated immediately after the explosion. 7500 w. Mines & Min—May, 1904. No. 62555 C.

Faults.

The Great East or Symon Fault of the Shropshire Coalfield. Explains the term and describes the Coalbrookdale Coalfield, discussing the effect of the Symon fault upon lower productive coal measures. 2700 w. Col Guard—April 29, 1904. No. 62612 A.

New Zealand.

The Discovery and Progress of the Nightcaps Colliery. An illustrated article giving the history of this coalfield. 2700 w. N Z Mines Rec—March 16, 1904. No. 62402 B.

Pocahontas.

Industrial and Labor Conditions in the Pocahontas Coalfields. George L. Fowler. Mr. Fowler's second article discusses the labor condition of the district, including the negro question and the practical working of the company store. 4000 w. En-

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gineering Magazine—June, 1904. No. 62-885 B.

Utah.

Mineral Resources of the Uinta Mountains. Charles P. Berkey. Reports meager mineralization, the richest resource known is in hydrocarbons. 1200 w. Eng & Min Jour—May 26, 1904. No. 62969.

West Virginia.

West Virginia Coal Mines. Information from the last annual report of James W. Paul, general mine inspector, concerning production, price, employees, wages, &c. 1700 w. Eng & Min Jour—May 12, 1904. No. 62648.

COPPER.

Arizona.

Notes on Geology of Mineral Creek District, Pinal County, Arizona. F. A. Gowing. Describes the topography, giving geologic facts, and describing copper and lead deposits. 3000 w. Min Rept—May 19, 1904. No. 62798.

The Clifton District, Arizona. An illustrated report of this district which has an output of about 60,000,000 lb. of copper a year. 2200 w. Eng & Min Jour—April 28, 1904. No. 62511.

The Copper-Deposits of the Kaibab Plateau, Arizona. E. P. Jennings. Describes the formation of the plateau, the ores, deposits, &c. 1000 w. Trans Am Inst of Min Engrs—Oct., 1903. No. 62941.

Australia.

English and Australian Copper Co. Donald Clark. Describes the works, processes and ores dealt with by this company. 2000 w. Aust Min Stand—April 7, 1904. Serial. 1st part. No. 62-703 B.

Concentration.

Concentration of Low-Grade Copper Ores. W. J. Adams. Gives results obtained in a series of tests made on the concentration of copper ores by the Elmore oil process. 1700 w. Min & Sci Pr—May 7, 1904. Serial. 1st part. No. 62661.

Deposits.

The Copper Deposits of Orange County, Vermont. Henry Lloyd Smith, and Philip S. Smith. Gives a summary of results of geological studies by students of Harvard University. 2200 w. Eng & Min Jour—April 28, 1904. No. 62510.

Impurities.

Relative Elimination of Impurities in Bessemerizing Copper-Matte. Allan Gibb. Discussion of the paper of W. Randolph Van Liew. 1700 w. Trans Am Inst of Min Engrs—Oct., 1903. No. 62942.

GOLD AND SILVER.

Alaska.

Unexplored Alaska. Information from a publication of the U. S. Geol. Survey, giving a story of a pioneer journey of 535 miles through Central Alaska, between the Yukon basin and the Arctic Ocean. 1100 w. Sci Am Sup—May 14, 1904. No. 62658.

British Columbia.

The Ore Deposits of Rossland, British Columbia. Edmund B. Kirby. Describes the geology of the deposits, the conclusions regarding their formation, the effect upon mining methods, &c. 4500 w. Can Min Rev—April 30, 1904. No. 62-498 B.

Canada.

The Alsek Mining District. W. M. Brook. An illustrated description of a new placer gold-field in the Northwest Territory of Canada, near the Alaska border, recently discovered. 800 w. Eng & Min Jour—May 12, 1904. No. 62649.

Colombia.

The Gold Deposits of Colombia (Les Alluvions Aurifères de la Colombie). A. Hutin. An account of the placer workings of San Carlos, Antioqua, Colombia. 1800 w. Revue Technique—April 10, 1904. No. 62815 D.

Concentration.

The Concentration of Gold and Silver in Iron-Bottoms. Myrick N. Bolles. Discussing the use of iron as an absorbent in separating the precious metals from mattes low in copper. Ills. 11300 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62927 C.

Crushing.

The Rise and Fall of Dry Crushing on the Hauraki Goldfield. Percy G. Morgan. Gives a general description of the dry-crushing practice, stating its advantages and disadvantages. 5600 w. N Z Mines Rec—March 16, 1904. No. 62-401 B.

Cyaniding.

Cyaniding Tailings at the Golden Jubilee Mine in Trinity Co., Cal. W. W. Merriam. A description of equipment, plant, treatment, &c. 13300 w. Cal Jour of Tech—May, 1904. No. 62627 C.

The Hendryx Cyanide Process. C. M. Fassett. An illustrated description of this process and statement of the claims made. 1200 w. Eng & Min Jour—May 5, 1904. No. 62567.

An Inexpensive Cyanide Plant. F. A. Malins. Describes a cheap and simple cyanide plant now in operation near Sheridan, Montana, giving details of working. Treats about fifty tons a day. 3000 w. Min Rept—May 5, 1904. No. 62559.

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Deposits.

A Nevada Ore Deposit. Samuel C. Will. Describes a deposit of alabandite, the sulphide of manganese, carrying silver. 1100 w. Min & Sci Pr—May 14, 1904. No. 62794.

Mexico.

Notes on a Trip to White Oaks, New Mexico. E. Percy Smith and Leon Dominian. Illustrated description of this mining camp, with notes on its development and production. Gold placers and veins. 2000 w. Eng & Min Jour—May 19, 1904. No. 62749.

Mine Working.

The Method Used in Working the Silver-Lead Mines of Santa Eulalia, Chihuahua, Mexico. Edward G. Cahill. Explains the conditions of these mines when undertaken by modern engineers, and describes the successful working of a deep mining camp, most of the shafts being below the 1,500 foot level. 2500 w. Cal Jour of Tech—May, 1904. No. 62625 C.

Ore Deposits.

Genesis or Ore Deposits at the Royal Mine, Hodson, Cal. William Forstner. Illustrates and describes these deposits, explaining their probable formation. 2500 w. Min & Sci Pr—May 7, 1904. No. 62660.

Pan Amalgamation.

Pan Amalgamation at the "Minas del Tajo," Rosario, Mexico. A. E. Drucker. Gives results of extensive experimenting with pan-amalgamation, and valuable points in regard to the preventing and saving of "floured" quicksilver. 4000 w. Cal Jour of Tech—May, 1904. No. 62626 C.

Placers.

The Distribution of Placer Gold in Oregon. C. W. Washburne. Abstracted from the *Bulletin Univ. of Oregon.* Information concerning this region. 1100 w. Min & Sci Pr—April 30, 1904. No. 62562.

Sulphide-Smelting.

Sulphide-Smelting at the National Smelter of the Horseshoe Mining Co., Rapid City, S. D. Charles H. Fulton and Theodor Kuntzen. Describes the smelting of dry siliceous ores, extracting the gold and silver values in a matte of low copper-percentage. 3500 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62936.

Tonopah.

Tonopah Mining Camps. Arthur Lakes. Some notes on its location, the geological formations of the region, and the mines in operation. Ills. 3600 w. Mines & Min —May, 1904. No. 62554 C.

Veins.

The Jimtown Mining District and Golden Age Mine. Arthur Lakes. A typical example of the intersection on their dip of two vein systems, and their influence on mining. 3000 w. Ills. Mines & Min —May, 1904. No. 62557 C.

Yukon.

The Opportunities for Gold Dredging in the Yukon. C. B. Bolger. States conditions in this region and describes a dredger which worked successfully. 1000 w. Min & Sci Pr—May 14, 1904. No. 62795.

IRON AND STEEL.

Bessemer.

The Synthesis of Bessemer Steel. F. J. R. Corulla. Read before the Iron & Steel Inst. Considers the proper employment of manganese the key to the Bessemer process, and discusses the proper proportion for different mixtures, and the value of the Bessemer process. 4500 w. Ir & Coal Trds Rev—May 6, 1904. No. 62735 A.

Blast Furnaces.

Furnace Top Explosions. Frank C. Roberts. A discussion of the theories most generally accepted in explanation of these "slips" in blast furnaces burdened with a high percentage of fine ore. 3000 w. Ir Age—May 5, 1904. No. 62516.

Stock Distribution and Its Relation to the Life of a Blast Furnace Lining. David Baker. Discusses mechanical handling and its difficulties, the need of careful handling of coke, and attempts made to reduce the tuyere destruction. Ills. 2500 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62930.

The Thermal Efficiency of the Blast Furnace. W. J. Foster. Read before the Iron & Steel Inst. An examination of the furnace at Dorlaston; the materials used were chiefly silicates of iron, in the form of flue and tap cinders, and a small quantity of ferric oxide. Experiments and results. 5000 w. Ir & Coal Trds Rev—May 6, 1904. No. 62734 A.

The Use of High Percentages of Mesabi Iron-Ores in Coke Blast-Furnace Practice. W. A. Barrows, Jr. Gives the writer's experience in handling furnaces with mixtures containing large portions of Mesabi ores. Also discussion by Edward A. Uehling and others. 5800 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62932 C.

Canada.

The Coal and Iron Resources of the Dominion of Canada. An illustrated review of the resources, discussing their value, development, &c. 12800 w. Ir & Coal Trds Rev—May 6, 1904. No. 62743 A.

Deposits.

The Iron Ore Deposits in Southern

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Utah. Fred Lerch. Information concerning the geology, the size and character of the ore bodies, quality of the ore and coal, facilities for cheap mining and the commercial prospects. Map. 2300 w. Ir Trd Rev—May 19, 1904. No. 62746.

Electric Smelting.

See Electrical Engineering, Electrochemistry.

Ferro-Silicon.

Explosions Produced by Ferro-Silicon. A. Dupre, and W. B. Lloyd. Gives the circumstances of the explosions, the cause, and precautions, to avoid future risk. 1400 w. Eng News—May 26, 1904. No. 62963.

Herrang.

The Manufacture of Pig-Iron from Briquettes at Herräng. Prof. Henry Louis. Read before the Iron & Steel Inst. Describes the mines, concentrating work, briquetting plant, blast furnace plant, and power station, giving general information. Ills. 5500 w. Ir & Coal Trds Rev—May 6, 1904. No. 62731 A.

Iron Making.

Influence of Raw Materials, Transport, and Labor on Iron Making Costs in Great Britain, United States, and Germany. An examination of the comparative conditions under which the principal industrial nations carry on their great industries. 7700 w. Ir & Coal Trds Rev—May 6, 1904. No. 62742 A.

Nitrogen.

Nitrogen in Iron and Steel. Ernst A. Sjostedt. A résumé of two articles in *Teknisk Tidskrift*, written by Hj. Braune and Clas Bolin, which should be of interest to furnace managers. 3000 w. Ir Age —May 5, 1904. No. 62519.

Ore Handling.

Modern Methods of Handling Iron Ore from Minnesota Mines to Pittsburg Furnaces. Charles H. Wright. Two-page plate, illustrations, and account of the ore-handling on the Great Lakes. 3500 w. Eng News—May 5, 1904. No. 62573.

The Movement of Iron Ore on the Great Lakes. Arthur J. Mason. An interesting illustrated description of the mining and ore handling methods in the Lake Superior region. General discussion. 5000 w. Jour W Soc of Engrs—April, 1904. No. 62640 D.

Rolling Mills.

Electrically Driven Rolling Mills. H. Koettgen. Condensed from a paper read at Duesseldorf before the Verein Deutscher Eisenhuettenleute. Discusses the problem of electric driving in its application to three-high mills, roll tables, reversing mills, &c. 4800 w. Ir Age—May 19, 1904. No. 62744.

Specifications.

Standard Specifications for Pig-Iron and Iron Products. Gives the specifications proposed by a sub-committee of the Am. Soc. for Testing Materials. 7000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 62928.

Statistics.

Some Statistics of the World's Iron and Steel Industries. William Pollard Digby. Statistics in regard to the respective supplies of iron ore in Germany and England as compared with the United States, showing the extent of the import and export trade in the United Kingdom, and the margin of profit of the iron industries. Also discussion. 8700 w. Jour Soc of Arts—May 6, 1904. No. 62621 A.

Steel.

Notes on the Production and Thermal Treatment of Steel in Large Masses. Cosmo Johns. Read before the Iron & Steel Inst. Describes briefly the practice of the works of Messrs. Vickers, Sons, & Maxim, Ltd., giving much valuable information. Ills. 4500 w. Ir & Coal Trds Rev—May 6, 1904. No. 62732 A.

Segregation and Diffusion in Steel. B. F. Weston. Considers the principle of segregation, and of diffusion, extreme cases, and results. 2000 w. Ir Age—May 19, 1904. No. 62745.

Steel Rails.

The Detection of the Finishing Temperatures of Steel Rails by the Thermo-Magnetic Selector. Albert Sauveur and Jasper Whiting. Describes a method seeming to fulfill all the requirements of efficiency in preventing the rolling of coarsely crystalline rails. Ills. 1600 w. Ir & Steel Mag—May, 1904. No. 62639 D.

See also Mechanical Engng., Materials.

MINING.

British Columbia.

The Ten Mile Creek Camp of the Nicola District. J. West Collis. An illustrated description of an interesting mineral belt, only needing transportation facilities to prove profitable. Workable coal seams, copper deposits, some gold and silver, &c. 2300 w. B C Min Rec—May, 1904. No. 62685 B.

Drills.

Rock-Drill Bits. T. H. Proske. Brief illustrated descriptions of various patterns. 800 w. Eng & Min Jour—May 5, 1904. No. 62568.

Dust.

Prevention of Dust in Mines. Charles B. Brodigan. From the *Pro. S. African Assn. of Engrs.* Describes the method of drilling used in constructing the Simplon Tunnel. 2500 w. N Z Mines Rec—March 16, 1904. No. 62403 B.

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Excavations.

The Support of Excavations in the Witwatersrand Mines. T. Lane. Carter An account of the conditions of these mines, the prevailing practice, and cost of timbering. Ills. 1200 w. Eng & Min Jour—May 5, 1904. No. 62565.

Explosives.

The Effects of Cold and Frost upon Explosives (Effets du Froid et de la Gelée sur les Explosifs). H. Schmerber. Showing that the advantages due to the safe storage of frozen explosives are largely offset by the dangers of thawing. 1800 w. Génie Civil—May 7, 1904. No. 62828 D.

Exposition.

Mining Exhibits at the Louisiana Purchase Exposition. A. H. Storrs. Gives the location and general arrangement of the exhibits of the various States. 4200 w. Mines & Min—May, 1904. No. 62556 C.

Faults.

Faulting in the Globe District. Frederick Leslie Ransome. Abstracted from "The Geology of the Globe Copper District, Arizona." Illustrates and describes this faulted region. 1700 w. Eng & Min Jour—May 19, 1904. No. 62750.

Gases.

Gases in Metalliferous Mines. Abstract of a paper by Harry A. Lee, read before the Colorado Sci. Soc. An account of the occurrence of free nitrogen gas in a vein in Colorado, and its effects on those breathing it. 1500 w. Mines & Min—May, 1904. No. 62553 C.

Geogenesis.

Geogenesis and Some of Its Bearings on Economic Geology. Persifor Frazer. Considers the nebular theory and the new hypothesis propounded recently by Prof. Chamberlin. 4000 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62931.

Gravity Incline.

A Gravity Incline at the Antonio Mine in Cuba. E. M. Holmes. Illustrates and describes this new incline and its working. It seems to prove large cars superior to small ones in such work. 600 w. Eng News—May 12, 1904. No. 62664.

Laboratories.

See Industrial Economy.

Mine Traction.

Catches for Inclined Cable Railways (Fangvowichtungen au Steilen Förderbahnen). H. Gertner. Illustrating various forms of safety for use with inclined mine hoists, both for chain and wire cables. 1800 w. Glückauf—April 23, 1904. No. 62847 B.

Electric Traction for Mines. A. J. Bloemendal. Shows the advantages and good results obtained at the installations at the Szaboles coal mines. Ills. 2000 w. Trac & Trans—May, 1904. No. 62704 E.

Mining Engineers.

The American Mining Engineer. Albert R. Ledoux. Presidential address discussing to what influences the superior efficiency of American mining engineers is due. 5300 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62937.

Nevada.

The Silver Peak Region, Nevada. J. E. Spurr. An illustrated description of this arid district, with report of the silver and gold mines. 1700 w. Eng & Min Jour—May 12, 1904. No. 62647.

Oil.

The Volcanic Origin of Oil. Eugene Coste. Takes exception to views of other writers, and presents evidence in support of his views that the origin of oil is inorganic and the result of solfataric volcanic emanations. 3500 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62929.

Prospecting.

Sizing Up Prospects. Arthur Lakes. Examining untried country to determine whether or not it is advisable to prospect thoroughly. Ills. 1500 w. Mines & Min—May, 1904. No. 62558 C.

Quarries.

The Ancient Stone Quarries Beneath Paris. Information translated from the *Annales des Mines* concerning the extensive underground quarries which greatly impaired the stability of the surface in Paris. Ills. 1000 w. Quarry—May, 1904. No. 62595 A.

Queensland.

The Queensland Mining Industry. Review of 1903, with maps showing mining leases, tabulated statistics and reports. Gold, copper, tin and coal all show substantial increases. 16000 w. Queens Gov Min Jour—March 15, 1904. No. 62474 B.

Rand.

Electricity in Rand Mines. Sidney F. Walker. A report of the use made of electricity in South Africa. 1200 w. Aust Min Stand—March 31, 1904. No. 62702 B.

Separator.

A Magnetic Separator. W. R. Crane. An illustrated detailed description of the Cleveland-Knowles electro-magnetic separator used at Joplin. 2000 w. Min & Sci Pr—April 30, 1904. No. 62563.

Sizing.

The Plotting of Sizing-Tests. W. Spencer Hutchinson. Describes experiments undertaken primarily for the purpose of measuring the quality of work done in screening and sorting in American concentrating mills. 6000 w. Trans Am Inst of Min Engrs—Feb., 1904. No. 62938 C.

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Stopes.

Ore Delivery from Stopes. E. L. Lefevre. Considers the meritorious systems of mill hole construction in general use. 2500 w. Min & Sci Pr—April 23, 1904. No. 62457.

Timbering.

Methods of Mining and Timbering in Large Ore Bodies in British Columbia and Michigan. Norman W. Parlee. Describes and discusses systems and their modifications as carried out in successful operation. Ills. 7400 w. Can Soc of Civ Engrs, Adv Proof—Feb. 25, 1904. No. 62433 D.

Mine Timbering in Section 16 of the Lake Superior Mining Company, Michigan. C. G. Campbell. Describes the location of the mine, the method of mining the ore, the management, &c., outlining the conditions, and describing the applications of different methods. Ills. 3500 w. Can Soc of Civ Engrs, Adv Proof—Feb. 25, 1904. No. 62435 D.

Wastes.

Wastes in Mining and Metallurgy. James Douglas. Address before the Mich. Col. of Mines. Notes examples of saving valuable elements in ore, and fuels in the present number. 1600 w. Eng & Min Jour—May 5, 1904. Serial. 1st part. No. 62564.

Winding.

Electric Winding. Gerald Hooghwinkel. Enumerates the most striking advantages of electric wire steam winding, describing the different systems employed on the Continent and in the United States, and giving details of a modern plant. 7500 w. Ir & Coad Trds Rev—May 13, 1904. No. 62952 A.

MISCELLANY.

New Constituent.

Troostite. Henry Cook Boynton. Read before the Iron and Steel Inst. Gives results of experiments presenting material which positively confirms the existence of troostite, with new facts related. 3000 w. Ir & Coal Trds Rev—May 6, 1904. No. 62738 A.

Platinum.

The Occurrence of Platinum in the Ural Mountains. Chester W. Purington. Gives citations from Russian authors, and recent papers on platinum, with translation from the *Bul. of Gold Min. Ind.*, St. Petersburg, "Concerning the Iss Platinum-bearing Region and the Distribution of Platinum in the Ural in General." Maps. 2000 w. Eng & Min Jour—May 5, 1904. Serial. 1st part. No. 62566.

Pyrrhotite.

Acid Making from Pyrrhotite. Ernest A. Sjostedt. Read before the Can. Min. Inst. Information and facts concerning the work done in treating the Sudbury pyrrhotite so as to recover the nickel, cobalt and copper, and to utilize the sulphur and iron contents. Ills. 4800 w. Can Min Rev—April 30, 1904. No. 62499 B.

Quicksilver.

A New Quicksilver Mining District. M. P. Kirk and J. W. Malcolmson. A report of the development work in Texas. 800 w. Eng & Min Jour—April 28, 1904. No. 62513.

Slimes.

Slime Treatment in the Joplin Region. W. R. Crane. An illustrated detailed description of the latest sludge mill built in the Galena district, showing the scheme of treatment. 1600 w. Eng & Min Jour—April 28, 1904. No. 62512.

Thermite.

The Production of Pure Metals and Metal Alloys by Means of Thermite. Dr. Alfred Gradenwitz. An explanation of the alumino-thermic manufacture of metals and alloys. 1200 w. Min Rept—May 19, 1904. No. 62799.

Zinc.

Zinc Ores in British Columbia. E. Jacobs. Gives a summary of the different deposits of zinc-bearing ores in the province, with remarks. 2000 w. Eng & Min Jour—May 26, 1904. No. 62970.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Accidents.

Accident Bulletin No. 10. Information from the last Bulletin issued by the Interstate Commerce Commission, with editorial comment. 4200 w. R R Gaz—April 29, 1904. No. 62509.

Car Distribution.

A Practical Method of Car Distribution. C. C. Riley. Read before the Car Accountants' Assn. Describes a system now in use on the Chicago Great Western. 2500 w. R R Gaz—May 27, 1904. No. 62967.

Car Interchange.

How Fairness is Secured in Car Interchange. From the Pittsburg *Commercial Gazette*. A discussion of former and present practice. 2200 w. Loc Engng—May, 1904. No. 62533 C.

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Danger Signal.

Railroad Fusees. J. C. Ramage and Lewis Cheeseman, Sr. Considers the composition and mechanical construction of fusees from the standpoint of safety, and the requirement which actual service demands of a good fusee. 3000 w. R R Gaz—May 13, 1904. No. 62674.

Fast Run.

Record Run on the L. S. W. Railway. Charles Rous-Marten. An account of a run between Plymouth and London. 1700 w. Engr, Lond—April 29, 1904. No. 62616 A.

The Fast Run Record Beaten on the Michigan Central. Gives the schedule of the run made by the President's Special, from Niagara Falls, Ont., to Chicago, Ill., on April 27, 1904. 700 w. Ry Age—May 6, 1904. No. 62561.

Records.

Recent British Railway Records. Charles Rous-Marten. Discusses the services on the London and Northwestern Railway and the Great Western Railway. 1800 w. Engr, Lond—May 13, 1904. No. 62775 A.

Trans-Siberian.

The Trans-Siberian Railway (Le Chemin de Fer Transsiberién). E. Lemaire. A fully illustrated account of the history of the road and of the details of its commercial operation. Serial. Part I. 2500 w. 1 plate. Génie Civil—May 7, 1904. No. 62826 D.

Workmen's Trains.

Workmen's Trains in England. Facts and general information concerning the development of this service, the frequency of trains, number of passengers, rates, &c. 5700 w. Ry Age—May 20, 1904. No. 62793.

MOTIVE POWER AND EQUIPMENT.

Brakes.

Electric Car and Train Brakes. S. J. Kidder. Abstract of a paper before the Air-Brake Assn. Considers the various types of brakes brought out since the adoption of electric power for operating cars and trains. 3200 w. R R Gaz—May 13, 1904. No. 62672.

Higher Train Pipe Pressure for Passenger Service. J. P. Kelly. Comments on the tests of high pressure brakes conducted on the Central R. R. of New Jersey, and the results obtained, with other matters related to high-pressure service. 2800 w. R R Gaz—May 13, 1904. No. 62673.

Car Disinfection.

On the Disinfection of Passenger Carriages, of Cattle Trucks, and of Goods Wagons. Dr. De Rechter. Discusses the conclusions adopted by the XIIIth International Sanitary Congress, showing the great variety of methods used in different countries. 5800 w. Brit Int Ry Cong—April, 1904. No. 62471 E.

Counterbalancing.

The Computation of Counterweights for Multiple-Cylinder Locomotives (Die Berechnung der Gegengewichte bei Zwei, Drei und Viercylinder-Lokomotiven). J. Kempf. An examination of the action of the disturbing forces for various crank positions, and the extent to which they can be balanced. Serial. Part I. 3000 w. Glasers Annalen—May 1, 1904. No. 62832 D.

Couplings.

Automatic Couplings for Railway Rolling Stock. Mr. Sauer. Abstract translation of a report of a series of trials made by Messrs. Fried. Krupp, of Essen, on Feb. 12, 1903, with illustrations of details of construction of automatic couplings. 6600 w. Bul Int Ry Cong—April, 1904. No. 62473 E.

Equipment.

New Passenger Equipment for the London & Northwestern Railway. Illustrated detailed description of recently built cars, among them two royal saloon cars. 2500 w. Ry Age—May 20, 1904. No. 62792.

Firing.

Firing Locomotives. F. R. Wadleigh. Instructions aiming to cover the vital points and to expose clearly the work required of the fireman. 2000 w. R R Gaz—May 13, 1904. No. 62671.

Freight Cars.

The New Fifty-Ton Freight Cars of the Douai Forge Company (Les Récents Wagons de 50-Tonnes Construits par les Forges de Douai). Col. Fix. Illustrating recent heavy freight cars for the French railways. 2500 w. Revue Technique—April 25, 1904. No. 62817 D.

Locomotives.

A Michigan Central 4-4-2. Illustration, with description of an Atlantic type passenger engine. 700 w. Ry & Loc Engng—May, 1904. No. 62530 C.

British Locomotives in 1903. Charles Rous-Marten. Remarks on the design and work of new types on the fifteen leading railways of Great Britain. 5400 w. Bul Int Ry Cong—April, 1904. No. 62472 E.

Cole's 4-Cylinder Balanced Compound Locomotive. Illustration, with description of an interesting engine which will form a part of the exhibit of the N. Y. C. & H. R. R. R. at St. Louis. 500 w. Am Engr & R R Jour—May, 1904. No. 62463 C.

English Three-Cylinder Compound on the Midland. Illustrated description of an engine which works the express passenger trains between Leeds and Carlisle. 700 w. Loc Engng—May, 1904. No. 62532 C.

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Locomotive Engine Details, Great Western Railway. Illustrations, with principal dimensions. 200 w. Engr, Lond—May 13, 1904. No. 62778 A.

Maintenance of Metallic Packing on Locomotives. P. A. C. King. Discusses the treatment packings should receive. 2000 w. Am Engr & R R Jour—May, 1904. No. 62466 C.

Mallet Articulated Compound for the Baltimore & Ohio. Illustrated description of a type extensively used in Europe, particularly adapted to heavy freight service on many grades with sharp curves. Inset. 1000 w. R R Gaz—May 27, 1904. No. 62968.

New Express Engines—Great Central Railway. Charles Rous-Marten. Illustration, with description of one of four new express engines of large and powerful type. These engines differ in important details, and are introduced for comparison with the view of determining which gives the best results. 3500 w. Engr, Lond—May 6, 1904. No. 62726 A.

New York Central 4-6-2 Engine. Illustration, with description of the heaviest type of passenger engine on this road. 1000 w. Loc Engng—May, 1904. No. 62531 C.

Pacific Type (4-6-2) Locomotives for the Michigan Central. Illustrated description of heavy locomotives for passenger service. 700 w. R R Gaz—April 29, 1904. No. 62508.

Road Tests of Consolidation Freight Locomotives. E. A. Hitchcock. A report of trials made, showing the engine performance, and also the losses incurred for the particular conditions encountered. 4500 w. Trans Am Soc of Mech Engr, No. 033—June, 1904. No. 62911 C.

Some Details of a Very Heavy Locomotive. Illustrates and describes details of the running gear of the 2-10-2 (Santa Fe) type, built for the Atchison, Topeka & Santa Fe Ry. 500 w. Am Engr & R R Jour—May, 1904. No. 62465 C.

Some Features of the Modern Locomotive. W. F. M. Goss. Extract from an address delivered before the Am. Soc. of Mech. Engrs. Discusses the limit of power and of draw-bar pull, boiler modifications, steam pressure, superheating, &c. 3300 w. Eng News—May 5, 1904. No. 62572.

Tank Locomotive for Heavy Suburban Traffic; Lancashire and Yorkshire Railway. Illustrated detailed description of a very powerful suburban locomotive. 600 w. Engng—May 6, 1904. No. 62719 A.

The New Locomotives of the Paris Belt Line (Les Nouvelles Locomotives au Chemin de Fer de la Petite Ceinture de Paris). J. Koechlin. Illustrating and describing recent tandem compound locomotives for local passenger service. 6000 w. 4 plates. Rev Gen des Chem de Fer—May, 1904. No. 62850 H.

Locomotive Testing.

Locomotive Testing Plant at the Louisiana Purchase Exposition. Information from Bulletin No. 2 of the Pennsylvania Railroad, which describes the plant, giving illustrations. 2000 w. Ry Age—May 13, 1904. No. 62690.

Locomotive Testing Plant at Swindon. A detailed description of this machine. 1000 w. Engr, Lond—April 22, 1904. No. 62423 A.

Locomotive Work.

Locomotive Work on the Great Western Railway. A brief review, with report of a recent run from Bristol to London on the train known as the "Flyer." 2000 w. Engng—April 29, 1904. No. 62614 A.

Railway Automobiles.

See Mechanical Engineering, Automobiles.

Suburban Cars.

Side-Door Steel Suburban Cars for the Illinois Central Railroad. Illustrated detailed description, with statement of the advantages. 3500 w. St Ry Jour—April 30, 1904. No. 62496 C.

NEW PROJECTS.

Cut-Off.

Railroading Across Great Salt Lake. Herbert I. Bennett. An illustrated article on the Ogden-Lucin cut-off on the Central Pacific division of the Southern Pacific. The most noteworthy achievement in bridge-and-fill work ever accomplished. 1500 w. Sci Am Sup—May 21, 1904. No. 62748.

PERMANENT WAY AND BUILDINGS.

Crossings.

Some Modern Appliances Connected with Railway Crossings and Points. Owen R. Williams. Describes and considers some appliances in regard to railway points and crossings, stating the reasons why they are needed, the qualities they should possess, &c. 3000 w. 3 plates. Trans Inst of Engrs & Shipbldrs in Scotland—April 26, 1904. No. 62619 D.

Location.

Railway Location in Victoria, Australia. D. M. Fraser. Deals with the application of the principles of economic railway location, as developed by A. M. Wellington, to the conditions in Australia. Chiefly considers light traffic railways. 13300 w. Eng News—May 12, 1904. No. 62668.

The Location of the Knoxville, La Follette and Jellico Railroad, of the Louisville and Nashville System. Discussion of W. D. Taylor's paper on this subject. 12800 w. Pro Am Soc of Civ Engrs—April, 1904. No. 62444 E.

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Machine Tools.

Special Machine Tools for Locomotive Shops. Joseph Horner. Illustrates and describes examples from British and Continental practice. 3700 w. Cassier's Mag —May, 1904. No. 62784 B.

Manchuria.

The Eastern Railway of China (Die Chinesische Ostbahn), with map of the Manchurian Section of the Trans-Siberian Railway, showing its branches and the development of the country traversed. 1000 w. Glasers Annalen—April 15, 1904. No. 62830 D.

Momentum Grades.

Momentum Grades: Some Comments on Their Literature and Their Probable Future Use. W. D. Taylor. Revises briefly papers giving information on this subject, with comments. 4800 w. Eng News—April 28, 1904. No. 62492.

Repairing.

Power Plant for Use in Track Repairing (Application de la Force Mécanique aux Travaux de Renouvellement des Vorés). M. Regnoul. Illustrating a portable electric generating plant for use with electric tools for repair work on any part of a railway line. 4500 w. Rev Gen des Chem de Fer—May, 1904. No. 62849 H.

Shops.

Shop Management, Organization and Methods. H. A. Lyddon. Read before the Northwest Ry Club. On the importance of having men of character and ability as heads of the various departments, discussing the present conditions. 4400 w. Ry & Engng Rev—May 13, 1904. No. 62696.

Signalling.

A Novel Block or Telephone Signal System. Describes a block or telephone signal system independent in itself, invented by Edward Rowe. 1400 w. Sci Am Sup —May 14, 1904. No. 62656.

See Electrical Engineering, Communication.

Stations.

Passenger Stations of the Illinois Central. Illustrations of 15 stations representing the most characteristic types in use on this road, with notes. 1200 w. R R Gaz —May 20, 1904. No. 62752.

Track Elevation.

Track Elevation of the Pennsylvania in Newark, N. J. An illustrated detailed description of the work of elevating about three miles of track without interrupting the heavy traffic. 2800 w. R R Gaz—May 6, 1904. No. 62575.

Turntable.

A Turntable of New Design. Illustrated description of an exhibit at the St. Louis World's Fair, of a design embodying several new features. 700 w. Ry & Engng Rev—May 21, 1904. No. 62796.

TRAFFIC.

Rates.

English and American Rates. George S. Gibb, in the London *Times*. A comparison, giving information not before available. Also editorial. 2800 w. R R Gaz—May 27, 1904. No. 62965.

Royal Docks.

The Great Central's Fish Traffic. An illustrated article describing the important traffic from the royal docks at Great Grimsby, and giving an account of the development. 4500 w. Ry Age—May 13, 1904. No. 62689.

MISCELLANY.

Apprentice Schools.

Apprentice Schools on English Railways. An interesting account of the instruction provided by English railways for apprentices. 2500 w. Am Engr & R R Jour—May, 1904. Serial. 1st part. No. 62464 C.

Mail Service.

Railway Mail Service in 1856. John Kirby. A brief history of the growth of the railway postal service between Toledo and Chicago in 1856, compared with the service between New York and Chicago at the present time. 1200 w. Ry Age—June 10, 1904. No. 63199.

Midland Railway.

Diamond Jubilee of the Midland Railway. W. B. Paley. A brief review of the history. 2300 w. R R Gaz—June 3, 1904. No. 63106.

The Diamond Jubilee of the Midland Railway. A condensed review of the history of this English railway. 1600 w. Engr, Lond—May 20, 1904. No. 63016 A.

N. Y., N. H. and H. R. R.

The Upbuilding of a Railroad System. Clarence Deeming. Begins an interesting review of the history of the New York & New Haven Railroad. 5500 w. R R Gaz —April 29, 1904. Serial. 1st part. No. 62507.

Timber.

Timber Treatment and Timber Treating Plants. Walter W. Curtis. Reviews the history of timber preservation, the methods, with statement of comparative costs, and other information. General discussion follows. 10700 w. Pro N Y R R Club—April 15, 1904. No. 62787.

We supply copies of these articles. See page 719.

STREET AND ELECTRIC RAILWAYS

Accidents.

Street Railway Accidents—Their Cause, Prevention and Adjustment. Henry W. Brooks, Jr. Discusses the subject in detail. 6500 w. St Ry Jour—May 14, 1904. No. 62646 C.

Brakes.

Electric Car and Tram Brakes. S. J. Kidder. From a paper read before the Air Brake Ass'n. Reviews briefly the various systems that have been tried. 3000 w. St Ry Rev—May 20, 1904. No. 62921 C.

Cable Railway.

The Cable Incline Railway at Hohensyburg (Die Drahtseil-Bergbahn nach der Hohensyburg). Otto Armknecht. Description of electrically driven incline cable road, 445 metres long, with a rise of 93 metres, near Hörde, Westphalia. Serial, Part I. 2500 w. Elektrotech Zeitschr—May 12, 1904. No. 62862 B.

California.

The Key Route Electric Railway Power Plant, Oakland, Cal. An illustrated detailed description of the plant provided for the San Francisco, Oakland & San Josè Railway, which has many features of interest. 2700 w. Eng Rec—May 7, 1904. No. 62578.

The Los Angeles & Redondo Railway. An illustrated description of an electric interurban system that was formerly a steam road. 4000 w. St Ry Jour—April 30, 1904. No. 62495 C.

The Street Railway and Ferry Systems of Oakland, Cal. Illustrated description. 900 w. St Ry Rev—May 20, 1904. No. 62918 C.

Car Houses.

Electric Railway Car Houses—Construction and Hazards. Ralph Swetland. From Bulletin of the Committee of the Nat. Fire Pro. Assn. Suggestions for safety as given in recently adopted requirements of the New England Insurance Exchange. 6000 w. St Ry Jour—May 21, 1904. No. 62903 C.

Colorado.

Trinidad Electric Railroad Co. Illustrated description of the plant, roadbed, and rolling stock of the new urban and interurban lines recently put into operation in Trinidad, Colorado. 1000 w. St Ry Rev—May 20, 1904. No. 62917 C.

Competition.

Railway and Tramway Competition in England. W. M. Acworth. A discussion of conditions in England, the reasons why competition has not become serious sooner, the policy to be adopted, &c. 2300 w. Ry Age—May 20, 1904. No. 62791.

Concrete Sub-Station.

The New Parkville Concrete Sub-station of the Brooklyn Rapid Transit Company. Illustrated description. 2000 w. St Ry Jour—May 7, 1904. No. 62583 C.

Control.

A Regenerative System of Tramcar Control. Illustrates and describes two recent British patents by J. S. Raworth for improvements in motors and regulating devices for electrically propelled vehicles. 2800 w. Elect'n, Lond—April 29, 1904. No. 62609 A.

Delays.

New System of Checking Car Service for Delays—Brooklyn Rapid Transit Company. Explains an effective system of reporting car service, with special reference to the tracing of irregularities of headway. 2000 w. St Ry Jour—May 7, 1904. No. 62582 C.

Despatching.

Train Despatching on the Rochester & Eastern Rapid Railway. An illustrated article giving interesting particulars regarding the telephone despatching system, and the apparatus employed. 2000 w. St Ry Jour—May 21, 1904. No. 62900 C.

Egypt.

A New Electric Railway in Alexandria, Egypt. An illustrated account of the electrification of the Alexandria & Ramleh Railway, and installation of electric traction upon the lines of the Alexandria Tramway Co. A high-voltage alternating-current transmission system with rotary converter sub-stations. 1700 w. St Ry Jour—May 7, 1904. No. 62580 C.

Electric Railways.

The Growth of an Electric Railway. L. E. Gould. Explains in a general manner the progress of an electric railway up to the date of its operation. 4000 w. St Ry Rev—May 20, 1904. Serial, 1st part. No. 62915 C.

Electrification.

Electric Traction on the Lancashire and Yorkshire Railway. An illustrated detailed description of the new service between Liverpool and Southport, and the changes made necessary in permanent way, rolling stock and equipment. 8600 w. Tram & Ry Wld—April 14, 1904. No. 62395 B.

Exposition Features.

Some of the Electric Railway Features

We supply copies of these articles. See page 719.

at the World's Fair, St. Louis. Winder Elwell Goldsborough. An illustrated article explaining the investigations to be carried out under the direction of the Electric Railway Test Commission. 1600 w. St Ry Jour—May 7, 1904. No. 62579 C.

Germany.

Financial Results of Electric Railway Operation in Germany. Gives particulars in regard to the profits made, cost of operating, fares charged, &c. The returns are less favorable than was anticipated. 2800 w. St Ry Jour—May 7, 1904. No. 62584 C.

Grounding.

The Grounding of the Neutral Point with Three-Phase Currents (Die Erdung des Neutralen Punktes bei Drehstromanlagen). Paul Humann. Discussing especially the losses due to the dielectric of the cable. 2000 w. Elektrotech Zeitschr—May 5, 1904. No. 62859 B.

High Speed.

Experiments in High-Speed Electric Traction on the Marienfelds-Zossen Line (Les Experiences de Traction Electrique Rapide sur la Ligne de Marienfelde-Zossen). Alfred Gradenwitz. An illustrated account of the experiments of 1901-1903, at speeds of 160 to 210 kilometres per April 15, 1904. No. 62841 D.

Interurban.

Practical Hints on Interurban Railway Operation. A. B. Herrick. Discusses some points in common practice that are not suited to interurban service. 2200 w. St Ry Jour—May 21, 1904. No. 62901 C.

Mountain Railway.

The Fayet-Chamouix Railway. Daniel Bellet. Outlines a plan for constructing a railway to the summit of Mont Blanc, and gives an illustrated detailed description of the Fayet-Chamonix electric railway, which connects the foot of Mont Blanc with the Paris-Lyons-Mediterranean System. 4500 w. Trac & Trans—May, 1904. No. 62705 E.

Mt. Vesuvius.

The New Mt. Vesuvius Electric Railway. Illustrated detailed description of the new railway from Naples to the base of the cable railway. The plans embrace the employment of ordinary and rack sections to be operated by electricity. 2000 w. St Ry Jour—May 7, 1904. No. 62581 C.

Narrow-Gage.

Narrow-Gage Road from Lausanne to Mondon. E. Guarini. Illustrated description of an interesting line in Switzerland. 1300 w. St Ry Rev—May 20, 1904. No. 62916 C.

New Hampshire.

Manchester Traction, Light & Power Co. Illustrates and describes the electrical power generation and distribution from the water powers along the Merrimac and Piscataquog Rivers. 3000 w. St Ry Rev—May 20, 1904. No. 62914 C.

Rail Conduction.

The Drop in Voltage in Alternating Traction Systems (Spannungsabfall von Wechselströmen in Eisenbahnschienen). Dr. H. Behn-Eschenburg. A discussion of the difficulties in using the rails as return conductors. 4500 w. Elektrotech Zeitschr—April 21, 1904. No. 62854 B.

Rail Joints.

Tramway Rail Joints. Discusses troubles with rail joints, their causes and remedies. 3800 w. Tram & Ry Wld—April 14, 1904. No. 62396 B.

St. Louis.

East St. Louis & Suburban Railway. Illustrating and describing the new power plant recently completed to replace several smaller plants of the consolidated companies. 2000 w. St Ry Rev—May 20, 1904. No. 62920 C.

Some Features of the East St. Louis & Suburban Railway. Brief illustrated description of this system, road and equipment, shops, &c. 2800 w. St. Ry Jour—May 14, 1904. No. 62645 C.

Testing.

Train Testing. Sydney W. Ashe. Considers such tests which are desirable to make when the car equipment is in an operative condition, such as insulation tests, motor capacity tests, speed time curves, &c. Ills. 2300 w. St Ry Jour—May 21, 1904. No. 62902 C.

Traction.

The Continuous-Current System and the Single-Phase System for Traction. H. M. Hobart. A defense of the continuous-current system is given in the present article. 2200 w. Elec Rev, Lond—April 29, 1904. Serial. 1st part. No. 62606 A.

Trolley Line.

The New Overhead Wiring of the Street Railways of Hanover (Die Neuerbaute Oberleitungsanlage der Strassenbahn Hannover). L. Liebenberg. A fully illustrated account of the wiring and feeders, including the arrangement for a number of intricate curves. 3000 w. Elektrotech Zeitschr—May 5, 1904. No. 62858 B.

Tube Railway.

The Great Northern and City Railway. H. C. Fyfe. A description of the line and power plant of the most recent tube railway of London. 3000 w. Engineering Magazine—June, 1904. No. 62881 B.

We supply copies of these articles. See page 719.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
American Shipbuilder. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brick Builder. *m.* Boston.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Cassier's Magazine. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.

Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Reporter. *w.* Denver, U. S. A
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Pacific Coast Miner. *w.* San Francisco.
Page's Magazine. *m.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Wiener Bauindustrie Zeitung. *w.* Vienna.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.